Testimony Prepared for the
Committee on the Judiciary, Subcommittee on Courts, Intellectual Property, and the Internet Hearing
"Lost Einsteins: Lack of Diversity in Patent Inventorship and the Impact on America's Innovation Economy"

Dr. Lisa D. Cook
Michigan State University
March 27, 2019

Chairman Johnson, Ranking Member Roby, and eminent Members of the Committee, thank you for the opportunity to testify today about "Lost Einsteins: Lack of Diversity in Patent Inventorship and the Impact on America's Innovation Economy."

Unequal access to invention and innovation can lead to suboptimal outcomes for individuals and for the economy as a whole. My research offers evidence that women and underrepresented minorities are less likely to participate in invention and innovation at each stage of the innovative process – training, the practice of invention, and commercialization of invention. For women and African American participants (or would-be participants), this can result in an earnings, income, employment, and wealth gap. For the economy as a whole, this can result in lower output and living standards. My and others' research calculates that the size of the economy could be roughly 3 to 4 percent higher if women and underrepresented minorities were included in the innovative process from beginning to end. That is, living standards could be higher for all Americans with a more inclusive innovative economy.

My research with Kongchareon in 2010 was the first study to systematically examine racial and gender gaps in invention and innovation. A current and burgeoning literature elucidates racial and gender gaps at each stage of the innovative process (see Appendix A).

The Gender and Racial Gap in STEM Education and Training

In the early stages of education and training in STEM fields, women and underrepresented minorities lag in participation in nearly each STEM field. This is first evident in the awarding of bachelor's degrees. Even though a higher proportion of total degrees were awarded to women in 2014, in STEM fields women were awarded only 35 percent of the degrees. For advanced degrees, women outnumber men in some STEM fields. In 2016, women received 53 percent of the doctoral degrees in biological science and 71 percent of doctoral degrees in psychology. In other STEM fields, they are barely present. In 2016, women received 23 percent of doctoral degrees in engineering and 17 to 18 percent of those in computer science and physics.

The recent literature on the gender and racial gap related to participation in STEM fields attempts to identify the factors affecting these differences. The older literature documents these gaps within various types of inventors. More recent papers attempt to identify both salient factors and outcomes associated with gender and racial differences in STEM participation, including the impact of social norms and gender stereotypes, peer effects, and professors' gender on test scores and college majors. The ones elucidating participation in inventive activity are the ones reviewed below.

The Gender and Racial Gap during the Practice of Invention

In the process of practicing invention and creating new knowledge or products, women and African Americans not only engaged at generally lower rates than their counterparts, but they also earn less and are employed less than their counterparts. In 2010, the median salary for whites was $72,000, and for African Americans, it was $56,000, which was 78 percent of the median salary for whites.[1] In 2015, this share had only moved slightly to 79 percent. While the median salary for men in the innovation economy in 2010 was $80,000, it was only $53,000 for women, or 66 percent of the median male salary. In 2015, it was $87,000 for men and $62,000 for women, which was 71 percent of the median male salary.[2] Among scientists and engineers, in 2015 African American unemployment was 4.7 percent compared to 2.9 percent for whites.[3] While employment rates are increasing among women and underrepresented minority scientists and engineers, unemployment rates vary significantly by gender and racial and ethnic group. The unemployment rate for African American women is higher than the unemployment rate for all scientists and engineers, nearly double that of all scientists and engineers, and more than double that of white women scientists and engineers. Unemployment for under-

[1] Salary data for 2015 are from NSF (2017).
[2] NSF (2017). As is true for any salary data, differences will vary across occupations, age groups, race and ethnicity, etc.
[3] NSF WMPD 2017 Digest. Data are for 2015.

represented minority men at just above four percent is higher than for white and Asian men and higher than the average for all scientists and engineers.[4]

The literature on gender and racial differences in the inventive process has evolved similar to the literature on STEM participation. The older literature focused on identifying the gaps, while the newer literature has focused on sources or correlates and outcomes.

A few papers in the last decade have focused on the misallocation of talent among inventors and other high-skilled workers. My research with Kongcharoen (2010) found that co-ed patent teams are more productive (at commercialization) than single-sex male or single-sex female patent teams. Hunt, Garant, Herman, and Munroe (2013) investigate the gender gap for commercialized patents. Using the 2003 National Survey of College Graduates, they show the gender gap among S&E degree holders is due primarily to women's underrepresentation in patent-intensive fields and patent-intensive job tasks. They also show that women with a degree in S&E patent little more than women with other degrees, meaning that an increase in the share of women with S&E degrees will not substantially close this gender gap. They find that women's underrepresentation in engineering and in jobs involving development and design explain much of the patent gap. Closing this gap could increase U.S. GDP per capita by 2.7 percent. My 2018 research with Yang executes a similar exercise using more recent data and find that GDP per capita would be 0.6 to 4.4 percent higher if more women and African

[4] Under-represented minorities include scientists and engineers who are black, Hispanic, and American Indian or Alaska Native. While the disaggregated data are not available, the unemployment rates in the innovation economy for these groups are somewhat similar. Data on gender by race and ethnicity are reported in NSF (2017), but the accompanying data do not allow this calculation to be made.

Americans received STEM training and worked in related jobs. Hsieh, Hurst, Jones, and Klenow (2018) analyze the gender and racial distribution for highly-skilled occupations over the long run, the last 50 years. They show the change in the occupational distribution since 1960 suggests that a substantial pool of innately talented women and African Americans in 1960 were not pursuing their comparative advantage, and this misallocation of talent affects aggregate productivity in the economy. They find one quarter of growth in aggregate output from 1960 to 2010 can be explained by an improved allocation of talent.

Bell, Chetty, Jaravel, Petkova, and John Van Reenen (2016) investigate the characteristics and life trajectories of inventors to develop a comprehensive portrait of U.S. inventors, develop a simple inventor lifecycle model with barriers to human-capital acquisition. They also explore the determinants of becoming an inventor using data on all patents granted between 1996 and 2014 linked to federal income tax returns, combined with data on standard test scores for elementary school children in the New York City public school system between 1989 and 2009. They find an income, race, and gender gap in invention that is primarily due to environment barriers in acquiring human capital – a lack of mentoring and exposure to careers in science and innovation in childhood – and not due to differences in ability. This evidence suggests policies that target low-income, underrepresented-minority, and female children may be more effective in closing the invention gap than top income tax policies. The Institute for Women's Policy Research, Milli, et al. (2016) predict the current slow but steady increase in the share of patents with any women inventor will result in gender parity in the year 2092 and recommend better tracking of progress, assistance with costs of securing a patent, improved gender diversity in STEM, and improved networking opportunities for women.

Gender and Racial Gap in Innovation

In the final stage of commercializing invention, or innovation, outcomes are starkly different. Women are only 8 percent of new hires at VC firms.[5] Female CEOs receive only 2.7 percent of all venture funding, while women of color get virtually none: 0.2 percent. Women and African Americans are often found in legal and marketing departments but are largely missing in technical positions and among executives and boards. In 2014, Fortune ranked several large tech firms based on recently released demographic data. With respect to women executives, One firm was ranked highest with women constituting 43 percent of leadership roles, and two firms were ranked lowest with 19 percent women in these roles. Women constituted just 18.7 percent of boards of S&P 500 firms in 2014, which was up from 16.3 percent in 2011. In 2015, 11 percent of venture capitalists were women, and two percent were African American.[6]

This is the stage where incomes can be high, and wealth generated can be substantial. It is also the stage at which one would observe the most unequal outcomes by gender and race. This is immediately apparent when considering the prominence of tech firms in the most valuable

[5] Economist (2017).
[6] Cited in Cook (2018).

public firms and the relative size of these firms. The trillion-dollar valuations of some tech firms put them roughly on par with the GDP of the Netherlands, Mexico, or Australia.

Workplace issues for women and minorities go beyond the opportunity to participate in invention and innovation. Recently, tech workers in the U.S. have demonstrated to protest sexual harassment and misconduct, lack of transparency (including forced arbitration for sexual harassment claims), workplace culture, and pay and opportunity inequality.

Among the Forbes list of richest people in the world, five of the top 10 derive their wealth primarily from the innovation economy. The nine tech firms with initial public offerings (IPOs) last year were valued at roughly $36 billion, and the most valuable one was valued at approximately $20 billion.

Entrepreneurs around the globe are amassing wealth in everything from cryptocurrencies to telecoms to bridal dresses. Daniel Ek, the 35 year-old co-founder and CEO of Spotify taught himself to write code in his early teens and started his first business when he was 14. In April 2018, when Spotify went public, he became the tech industry's newest billionaire. On the close of the first day of trading the company was valued at over $26 billion, with Ek’s share worth nearly $2.5 billion. Tech entrepreneurs continue to dominate the list of the world’s billionaires. In the first half of 2018, 11 new tech entrepreneurs became billionaires when companies they founded went public, were acquired, or had new funding.[7]

[7] Forbes (2018).

This is the stage where gender and racial gaps have been covered the least in the academic literature. My 2010 research with Kongchareon and 2018 research with Yang 2018 include systematic analyses of commercialization of invention by race and gender, but, case studies in the business literature notwithstanding, this is typically not the focus of academic inquiry. Having better data could aid researchers in doing such analysis and aid economic policymakers in improving living standards of all Americans.

Conclusion

In the last two decades, researchers have made substantial progress in studying the participation of women and African Americans at each stage of the innovation process. After the facts of their participation were established, the focus of economists and other scholars has been on sources or correlates and outcomes and increasingly on mechanisms to understand causal factors.

If the aforementioned losses to GDP are being tolerated, firms, technology officers, and patent teams are not being good stewards of America's human capital and inventive capacity. This is a classic coordination problem and market failure. Public policy can help in the research, analysis, and promotion of diverse participation in inventive activities. Legislation, such as H.R. 5768, would be critical to researchers to develop this research further. Having patentees or their agents and attorneys voluntarily and separately report demographic data – gender, race, ethnicity – upon submission of a patent or other IP application would advance this important line of research further with more precise data. Having the USPTO report on these data annually will shed light on important dimensions of the problem and changes over time. I would propose adding two additional data series for collection: disability status and veteran status. The literature on innovation related to the inclusion of these groups is just developing, and this would be an opportune time to include these inventors in the counts proposed in the legislation, which would be in line with data collected by the Small Business Administration, for example.

Thank you, again, for the opportunity to speak to you today about the timely and important issue of building an inclusive innovative economy that has the potential to raise living standards for all Americans.

References

Ashcraft, Catherine and Anthony Breitzman. 2007. "Who Invents IT? An Analysis of Women's Participation in Information Technology Patenting". National Center for Women and Information Technology.

Avilova Tatyana and Claudia Goldin. 2018. "What Can UWE Do for Economics?". NBER Working Paper No. 24189.

Bayer, Amanda and Cecilia Rouse. 2016. "Diversity in the Economics Profession: A New Attack on an Old Problem". *Journal of Economic Perspectives, 30(4): 221-42.*

Becker, Charles M. , Cecilia Elena Rouse, and Mingyu Chen. 2014. "Can a Summer Make a Difference? The Impact of the American Economic Association Summer Program on Minority Student Outcomes". NBER Working Paper No. 20407.

Bell, Alex, Raj Chetty, Xavier Jaravel, Neviana Petkova, and John Van Reenen. 2016. "The Lifecycle of Inventors".

Bhardwaj, Prachi 2018. "Meet the 11 new tech billionaires that emerged in 2018," *Business Insider*, July 14.

Bostwick, Valerie K. and Bruce A. Weinberg. 2018. "Nevertheless She Persisted? Gender Peer Effects in Doctoral STEM Programs". NBER Working Paper No. 25028.

Buser, Thomas, Muriel Niederle, and Hessel Oosterbeek. 2014. "Gender, Competitiveness, and Career Choices". *The Quarterly Journal of Economics,* 129(3):1409–1447*.*

Carrell, Scott E., Marianne E. Page, and James E. West. 2010. "Sex and Science: How Professor Gender Perpetuates the Gender Gap*". The Quarterly Journal of Economics,* 125(3):1101-1144*.*

Chetty, Raj, Nathaniel Hendren, Frina Lin, Jeremy Majerovitz, and Benjamin Scuderi. 2016. "Gender Gaps in Childhood: Skills, Behavior, and Labor Market Preparedness: Childhood Environment and Gender Gaps in Adulthood". *American Economic Review: Papers & Proceedings 2016,* 106(5):282–288.

Cook, Lisa D. 2018. "Unequal Opportunity: The Innovation Gap in Pink and Black," in Eric Hintz, Marie Stettler Kleine, and Matthew Wisnioski, eds., *Does America Need More Innovators?* Forthcoming MIT Press.

___________ and Jan Gerson. 2018. "The Idea Gap in Pink and Black: A Literature Review," mimeo, Michigan State University.

___________ and Chaleampong Kongcharoen. 2010. “The Idea Gap in Pink and Black.” NBER Working Paper No. 16331.

___________ and Yanyan Yang. 2018. “The Life Cycle of the Innovation Gap in Pink and Black.” Michigan State University.

Ding, Waverly W., Fiona Murray, and Toby E. Stuart. 2006. “Gender Differences in Patenting in the Academic Life Sciences". *Science (313): 665-667.*

The Economist. 2017. “Girl power: How having a daughter boosts investors' returns,” September 30.

Feng, Venus, Jie Ma, and Pei Yi Mak. 2018. “China Gets Four New Billionaires in a Week After Battery IPO,” *Bloomberg*, June 14.

Fryer, Jr., Roland G. and Steven D. Levitt. 2010. “An Empirical Analysis of the Gender Gap in Mathematics”. *American Economic Journal: Applied Econ*omics, 2: 210–240.

Hsieh, Chang-Tai, Erik Hurst, Charles I. Jones, and Peter J. Klenow. 2013. “The Allocation of Talent and U.S. Economic Growth”. NBER Working Paper No. 18693.

Huddleston Jr., Tom. 2018. “How Spotify's college-dropout founder became a self-made millionaire at 23 — and a billionaire at 35,” *CNBC*, April 4.

Hunt, Jean-Philippe Garant, Hannah Herman, and David J. Munroe. 2012. “Why Don't Women Patent?”. NBER Working Paper # 17888.

Kahn, Shulamit and Donna Ginther. 2017. “ Women and STEM”. NBER Working Paper # 23525.

Milli, Jessica, Emma Williams-Baron, Meika Berlan, Jenny Xia, and Barbara Gault. 2016. “Equity in Innovation: Women Inventors and Patents.” *Institute for Women’s Policy Research*, November 29.

Nollenberger, Natalia, Núria Rodríguez-Planas, and Almudena Sevilla. 2016. "The Math Gender Gap: The Role of Culture." *American Economic Review, 106 (5): 257-61.*

Whittington, Kjersten Bunker. 2009. “Patterns of Male and Female Scientific Dissemination in Public and Private Science” in *Science and Engineering Careers in the United States: An Analysis of Markets and Employment*, edited by Richard B. Freeman and Daniel L. Goroff, 195–228. Chicago: University of Chicago Press.

Zölitz, Ulf, and Jan Feld. 2017 “Understanding Peer Effects – On the Nature, Estimation and Channels of Peer Effects”. *Journal of Labor Economics 35(2).*

Appendix: A Review of the Literature[8]

Kahn and Ginther (2017) summarize research on the underrepresentation of women in math-intensive science fields. They examine how culture, gender stereotypes, role models, competition, risk aversion, and other factors contribute to the gender STEM gap. They examine the progression of the STEM gap through school, starting at childhood, solidifying by middle school, and affecting women and men as they progress through school, higher education, and into the labor market.

Nollenberger, Rodríguez-Planas, and Sevilla (2016) focus specifically on the effect of gender-related culture on the math gender gap. They analyze math test scores of second-generation immigrants, finding that immigrant girls whose parents come from more gender-equal countries perform better than those whose parents come from less gender-equal countries. They find the transmission of cultural beliefs on the role of women in society contributes to the math gender gap.

Fryer and Levitt (2010) explore the math gender gap that emerges when children are in elementary school and examine the extent to which it is due to social norms or socialization. Their results document the emergence of a large math gender gap for elementary school children in the U.S. in every stratum of society, but they were not able to document any particular causal pathway. There is a bit of a puzzle in results from international data sets.

[8] This literature review relies heavily on Cook and Gerson (2018).

They find a negative relationship between gender inequality and female math performance in one international data set, but when they use another data set including Muslim countries, the gender math gap disappears for same-sex schools.

Carrell, Page, and West (2009) focus on the role professors' genders have on men and women's college majors. In math and science classes they find a professor's gender has little impact on male students. In contrast, for female students, the professor's gender has a noticeable effect on their performance, subsequent enrollment in math and science courses, and pursuit of a STEM degree. If high-performing female students' introductory math and science classes are taught by female professors, the gender gap in course grades and STEM majors is eliminated. This gender effect is not present in humanities classes.

Zölitz and Feld (2016) examine gender peer effects in a university context and how they influence students' choice of major and labor-market outcomes. Women who are randomly assigned to more women peers become less likely to select male-dominated majors and wind up in jobs where they work fewer hours and their wage grows at a slower rate than their male counterparts. Unlike women, men become more likely to select male-dominated majors after having had more female peers, and their labor-market outcomes are unaffected. Their findings suggest that the increasing female university enrollment in recent decades has inadvertently contributed to the occupational segregation among college graduates that persists in the labor market.

Recent work by Bostwick and Weinberg (2018) focuses on mechanisms associated with attrition by women in STEM doctoral programs. Specifically, they examine gender peer effects on persistence and degree completion in STEM doctoral programs. They demonstrate that women entering cohorts with no female peers are 11.9 percentage points less likely to graduate within six years than their male counterparts. They find that a one-standard-deviation increase in the percentage of female students differentially increases the probability of on-time graduation for women by 4.6 percentage points. They also find that these gender peer effects principally operate through changes in the probability of leaving after the first year of a Ph.D. program and are largest in programs that are typically male-dominated.

Niederle and Oosterbeek (2014) examine data from the Netherlands to investigate whether gender differences in competitiveness explain gender differences in education and labor market outcomes. They find boys are substantially more competitive than girls. This competitiveness is strongly and positively correlated with choosing more prestigious academic tracks that are more intensive in math and science. Their evidence is suggestive that differences in competitiveness explain roughly 20 percent of the gender difference in the choice of academic track.

Chetty et al. (2016) examine the extent to which family characteristics and childhood environment are the cause of gender gaps in employment, earnings, and college attendance for adults. They use the dataset constructed by Chetty et al. (2014) derived from U.S. tax returns data from 1996–2012 to show with graphs and regression analysis the correlation between how a child grows up and his/her adult outcome. The data support the conclusion that gender gaps in adulthood are rooted in the environment children grow up in, with the effect of being disadvantaged in childhood having more of a negative long-term effect on boys --- not the traditional gender gap you research.

In a number of recent papers, economists have turned their attention to the issue of stagnant or declining participation by women and underrepresented minorities in one particular STEM field, economics. Avilova and Goldin (2018) point out that men outnumber women as undergraduate economics majors by three to one nationwide, and even at the best research universities and liberal arts colleges men outnumber women by two to one or more. The authors report results from the Undergraduate Women in Economics Challenge, begun in 2015 as an RCT with 20 treatment schools and at least 30 control schools to evaluate whether better course information, mentoring, encouragement, more relevant instructional content, and other measures could increase women's interest in majoring in economics. Although the RCT is still in the field, results from several within-treatment-school randomized trials suggest that straightforward and inexpensive interventions can make a difference. Becker, Rouse, and Chen (2014) estimate the effectiveness of the AEA's summer program, launched in the 1970's, in increasing racial and ethnic diversity in the economics profession. They find that program participants were over 40 percentage points more likely to apply to and attend a PhD program in economics, 26 percentage points more likely to complete a PhD, and about 15 percentage points more likely to ever work in an economics-related academic job. According to these estimates, the summer program may directly account for 17 to 21 percent of the PhDs awarded to minorities in economics over the past 20 years. Bayer and Rouse (2016) present data on the relative lack of women and minority groups in the economics profession and review current research on the reasons for the imbalance. They argue that implicit attitudes and institutional practices may contribute to the imbalance at all stages of the pipeline, beginning at the undergraduate level and continuing throughout the academy, with little improvement over time. They review evidence on how diversity affects productivity, concluding that the lack of diversity is likely to constrain the range of issues economists address while limiting their ability to understand familiar issues from new and innovative perspectives. Bayer and Rouse propose measures to augment diversity in the economics profession along with evidence on their effectiveness and identify some promising practices, programs, and areas for future research. Most, if not all, authors on this set of papers addressing issues of participation in the STEM field of economics are or have recently been actively involved in programs designed to increase the number of minorities and women in the economics profession.

Goldin (2014) develops a personnel economics theory of occupational pay differences to explain the gender gap. Using census microdata and survey data to construct women's earnings penalty by occupation, Goldin finds that technology occupations typically are associated with more gender equality, which supports her theoretical model and confirms that changes in the structure of work and more temporal flexibility of jobs reduce the gender gap.

Whittington's (2009) research examines how the organization of work environments explains the invention and innovation gender gap in publishing and patenting across sectors and disciplines. Using the 1995 NSF Survey of Doctoral Recipients and inventor-level information from U.S. patents filed between 1976 and 2002 in the Boston region, Whittington finds the organization of the work setting, e.g., the broadly distributed work of academic science compared to the more horizontally distributed knowledge in biotech firms, the level of hierarchy and the structure of collaboration networks in the work setting, plays a significant role in explaining the gender gap in invention and innovation.