National Science Foundation Workshop Report

HTF (the Future of Work at Human-Technology Frontiers): Understanding Emerging Technologies, Racial Equity, and the Future of Work

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Introduction

The disappearance of stable work and the precarity of employment is a growing problem in the US, but its effects are not evenly distributed (NASEM 2017). The race gap in pay, and lack of racial diversity in the science and engineering workforce who is responsible for designing technology, are problems that converge with changes in technology and work. These problems are compounded by spatial segregation, favoring skill-rich areas and leaving vulnerable populations further isolated. Additionally, the organization of work has changed alongside emergent technologies, and not always in positive ways. At the same time, emergent technologies like those powered by artificial intelligence (AI) could offer much promise for the development of new human-technology relationships, and the future of work. Both the scope of the issue (work across many if not most sectors is affected by these emergent technologies), and the durability of the existing inequalities in work (especially by race but also gender) that are important to avoid replicating in new technologies, cry out for a convergence approach. Convergence, as a knowledge production approach (Roco and Bainbridge 2013), promises frameworks that can address the intertwined challenges of understanding emerging technologies and racial equity in workplaces. For the convergence of understanding emerging technologies, racial equity, and changes in work to progress, complex measurement and conceptual issues must be addressed. If current AI research efforts in academia and industry do not draw on the expertise of social scientists, there is a danger of reproducing existing inequalities in both the processes and products of that development. And if current social science efforts to understand inequality do not draw on the expertise of computer scientists and engineers who are designing new work systems, the understanding can at best be partial.

This project considered five thematic areas related to automation, racial equity, and work: (1) historical labor market vulnerability and who gets replaced when technology advances, (2) the use of AI to empower and enable participation in the job market, (3) who designs emerging technologies, and how knowledge production can be imagined in equitable ways, (4) the intersecting geographies of industry, skill, and race in an AI-transformed economy, and (5) stakeholder interests and how automated vehicles will change the driving landscape. The main goals of this project were to: (a) convene experts in social sciences, computational sciences, and engineering in order to articulate the social and technical dimensions for understanding the challenges of shaping emergent technologies that are equitable and result in "good" jobs for a wider range of workers, and (b) gain stakeholder feedback on the academic conversation in terms of feasibility, remaining questions and gaps, and the best potential sites for conducting the research envisioned at the academic experts workshop. These goals were accomplished through three separate workshops.

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Overview of the Three Workshops

Local academic workshop (March 2018): The first workshop convening academic colleagues on our campus was designed to develop the questions and discussion format for interdisciplinary faculty discussions on the five themes. The local academic workshop took place March 5th, 2018, at the University of Massachusetts Amherst.

National academic workshop (April 2018): The second workshop convened academic colleagues from around the country and across different disciplines within social sciences, computer sciences, and engineering. This core NSF workshop of the project was designed to identify the research gaps and research agenda for the five thematic areas. The national academic workshop took place April 5-6th, 2018, at the University of Massachusetts Amherst.

Regional Stakeholders workshop (June 2018): The final workshop convened stakeholders from the private, public, and nonprofit sectors in New England in order to provide feedback on the research agenda that emerged from the academic workshops. The regional stakeholders workshop took place June 18th, 2018, at the University of Massachusetts Club in Boston, MA.

Format: Each workshop included brief (5 minute) presentations from the PIs, breakout group discussion sessions, larger group report back sessions, and closing remarks from PIs on next steps. Participants were divided into five breakout groups based on the five themes. The assignment to group was based on discipline and familiarity and interest in the theme, with each group having representation from the three fields (computer science, social sciences, and engineering for the academic workshops and public, private, nonprofit sectors for the stakeholder workshop) (see Appendices A and B).

Keynote speakers: The national academic workshop featured keynote presentations by Moshe Vardi, Enobong (Anna) Branch, and Ruha Benjamin. The April workshop opened with a public talk that featured a keynote address by renowned computer scientist Moshe Vardi (Rice University) followed by a Critical Reflection on Racial Inequalities in the US Workforce and the Future of Work by Co-PI Enobong (Anna) Branch, a sociologist and demographer. The national academic workshop also featured a lunchtime talk by Ruha Benjamin (Princeton University), a renowned sociologist and Science/Technology Studies (STS) scholar, entitled Captivating Technology: Reimagining Race, Innovation, and Equity in Everyday Life. The June regional stakeholders workshop in Boston began with a keynote presentation by Victor Woolridge, Managing Director of Barings Real Estate Advisers and Chairman of the UMass Building Authority.

Participants: Each workshop was attended by the five members of the PI team, and was supported by designated note-takers. The participants of the two academic workshops came from a broad range of disciplines within the social sciences, computer sciences, and engineering (see Appendices C and D). The local academic workshop included 23 faculty members from departments across four colleges at the University of Massachusetts. The national academic workshop included 37 participants from academic institutions across the United States, representing diverse backgrounds by discipline, career stage, gender, racial and national identity. The stakeholder workshop included 20 participants who were community organization members, public and private sector leaders, and also represented a diverse group in terms of career stage, educational background, gender and race (see Appendix E).

Academic Workshops: Research Gaps and Agendas

The main questions of the workshop were addressed in the five thematic roundtables, each led by a member of the PI team. Each section below presents the research gaps identified by the local and national scholars, and their proposed research agenda.

Theme 1: Intersectionality of Race, Gender, and Skill (Branch)

Historical trends indicate the relational nature of occupational opportunity and how ethnic minorities are typically the most vulnerable to technology changes. Using the experience of Black women in the labor market as an analytical starting point, consider the relational nature of occupational opportunity such as how access is granted to some members of the workforce and withheld from others. One of the major questions in thinking about technology and the future of work is how automation interacts with persistent racialized and gendered inequalities. Given economic shifts over the past half century that have increased inequality in the United States, how does automation accelerate these trends, and further segment the labor market along racial and gender lines?

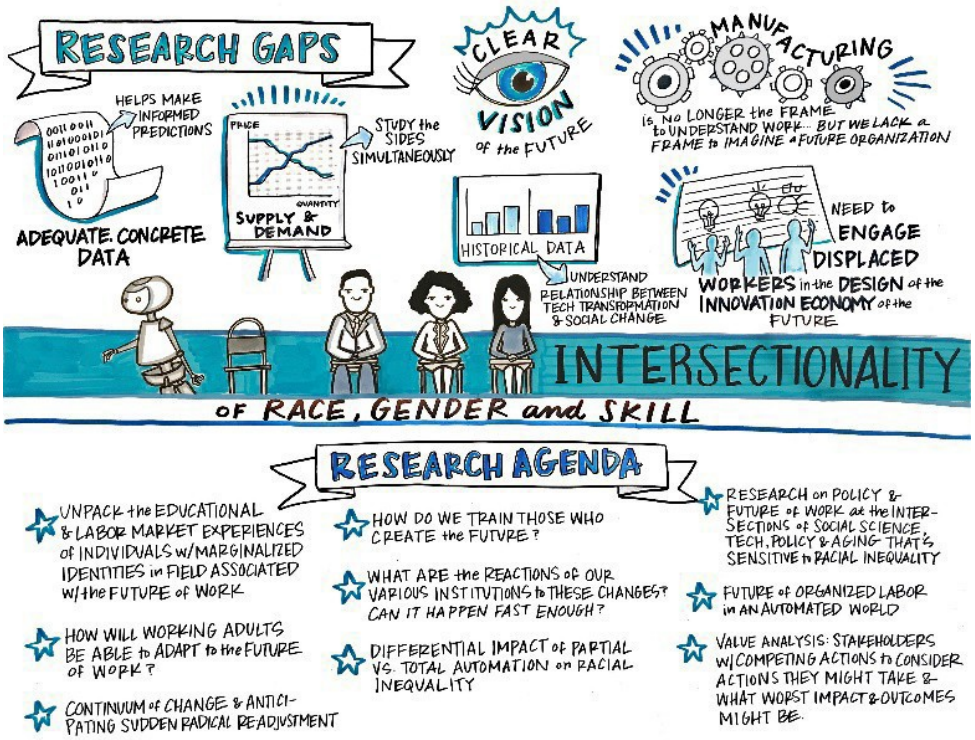

Figure 1. Graphic representation of Research Gaps and Agenda from April 2018 Workshop at PI Branch's roundtable on "Intersectionality of Race, Gender, and Skill: Historical Labor Market Vulnerability"

Research gaps identified by academics:

- *Data, data, data*

When thinking about the inequalities in the workforce, experts do not have adequate, concrete data to make informed predictions about how automation will exacerbate labor market divisions. Existing data are mostly anecdotal or have not kept up with changes in technology. Additionally, data sources fail to consider both the supply AND demand sides to the labor market. In other words, we need to know what is being currently being demanded of the labor force, and where demand trajectories are going.

- *Existing organization of work*

How much of what we think about work is influenced by how it is organized today, and what are the benefits and limitations of this perspective? All segments of the labor force are likely to be affected by automation to varying degrees; how will automation affect the work process in jobs that remain? Much of how we think about the impact of technology focuses on manufacturing, which may no longer be the dominant framework for understanding work. Development of a better frame for imagining the future of the workplace is needed.

- *Need a clear vision of the future*

Researchers cannot know the full potential or possibly grim futures of automation. Will we see a new wave of change that workers will adjust to or a radical transformation in the organization of work? The question for inequalities is whether it is more important to deal with the persistent inequality issues as they presently exist or focus on a future that may or may not come. What can be done to better prepare the workforce for technological changes that are happening now? What regulatory issues need to be addressed? Mindfulness to intersectional identities is needed in considering these questions about the future of work.

- *What can we learn from historical data?*

What lessons can we learn from previous changes in sociotechnical systems? Researchers need better comparative historical data that attends to the inseparable relationship between technological shifts and social change—including views of technology as social. History matters. What does the history of the labor movement tell us about the worker response to automation?
What are the conditions that drive collective action at work?

- *Hearing from workers*

In order to understand how these changes are experienced, researchers need more qualitative data from workers on the ground. We need to engage workers from the most vulnerable communities about their experiences with automation. These data could be combined with data from people in technology production design (see section on Knowledge Production below), with the goal of a more inclusive view of the research and development (R&D) sector that includes workers affected by automation.

Proposed research agenda:

- *Educational and labor market experiences*

Research is needed on the educational and labor market experiences of marginalized people. How are nontraditional students able to adapt to the future of work? What are the paths that open opportunities and encourage a shift towards lifelong learning? Multiple methods are needed. For example, a longitudinal study of a cohort of Black women that pairs survey data with a series of follow-up interviews exploring their experiences could provide important insights

- *Stakeholder Responses and Values*

What are the reactions of the various major organizations and stakeholders to technological changes? What are the responses of K-12 educational institutions, political agents, industry, regulatory offices, and non-government organizations to automation and the possibility of inequalities those organizations may exacerbate or create? Are these responses effective, and are they happening quickly enough? Another need is to examine the values of stakeholders with competing interests. Detailed value analyses can help with understanding what issues are important to stakeholders, how they develop shared values that result in coalition, as well as influence other stakeholders.

- *Varieties of automation*

What are the impacts of partial automation versus total automation on racial and gender inequalities? Additionally, do present changes represent a continuum of change or a sudden, radical readjustment in the organization of work?

- *Training Producers*

How do we train those who create automation? Integration of social science considerations of inequality into training for other STEM disciplines is needed. What are the effects of social science and ethics courses? Are there different outcomes for STEM programs that offer those courses?

Theme 2: AI and the Future of Work (Zilberstein)

AI and robotics are transforming the labor market — a process that is expected to intensify over the next decade. This process leads to the creation of new jobs and reduction or elimination of others. It is not a balanced phenomenon: it affects more dramatically those with lower levels of skills and less resources to retrain and adapt. There is no consensus among computer experts and social scientists about the ultimate outcome. Predictions range from massive reductions in the overall workforce and social unrest to more optimistic views of more opportunities and entirely new jobs. Naturally, it is easier to identify the jobs that might be eliminated than imagine the new types of jobs that will be created. Here, experts examined the role of AI in transforming the future of work, and particularly ways to use artificial intelligence to address the challenges and mitigate the negative impacts.

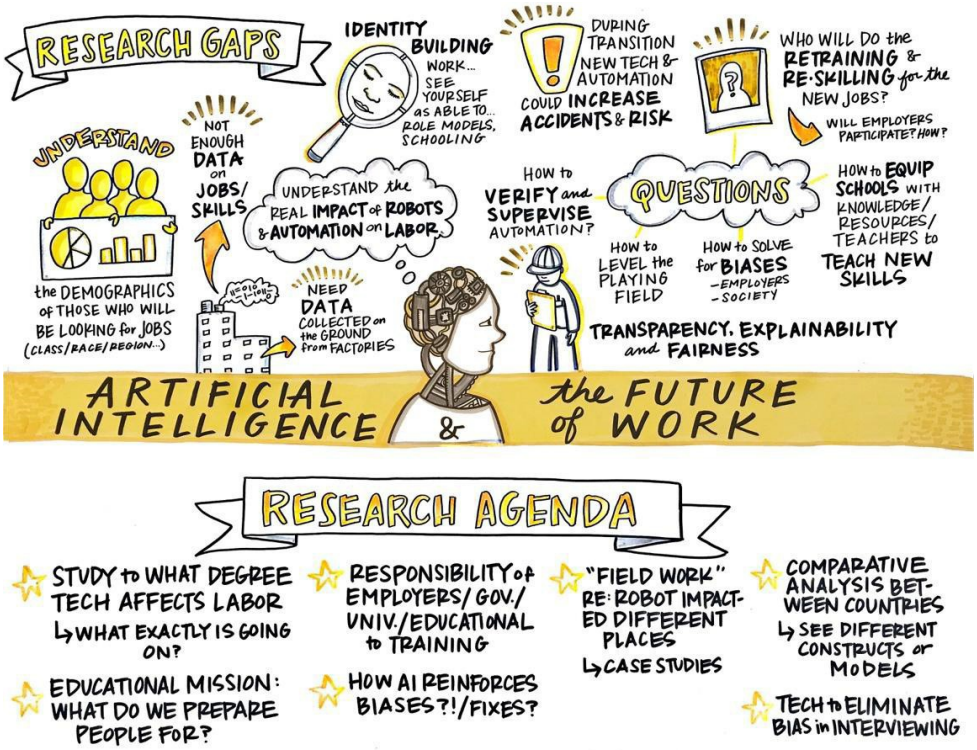

Figure 2. Graphic representation of Research Gaps and Agenda from April 2018 Workshop at PI Zilberstein's roundtable on "Artificial Intelligence & the Future of Work"

Research gaps identified by academics:

- *Current data on the effect of AI on employment is incomplete*

For example, existing studies about impact take robot purchase data and apply it to commuting zones. However, higher number of purchases does not necessarily mean higher unemployment. Additionally, not much data is being gathered on the ground, qualitative studies of people affected are needed.

- *What will be the relevant skills for the future job market? Who is going to be in chargeof teaching these skills?*

It is not clear how to identify the skills that are necessary (e.g., teaching programing at schools without any connection to what skills are needed for jobs). Furthermore, the skills gaps may involve complex skills such as critical thinking skills that are not emphasized at community colleges or high schools. In the case of high-school education: how to address the issues of standardization and lack of teachers?

- *How to prepare for incoming demographic shifts?*

For example, prisoners who are soon going to be released from prison and need to be integrated into a rapidly changing job market.

- *How to achieve explainability, accountability and fairness in AI?*

Can fairness be defined precisely, and how to do we produce analytic tools to understand existing biases in currently used systems?

- *How is the introduction of automation going to affect workers accustomed to different work patterns?*

We need to consider biases in organizational change. How do workers interact with technological systems that are not like them? Also, how do we create paths towards expertise? Most entry-level workers start doing work that is easier to automate. After job loss, what is the pathway towards higher-level positions? AI research should propose technologies that empower and enable participation in the job market, and increase equity and diversity. For example, unbiased technologies that help people find available jobs and identify the necessary training, systems to support self-training, and reduce the costs of retraining via online resources.

Proposed research agenda:

- *Education and Skills Building*

Study the current gap between the skills that employers seek and the skills that workers have. What is that gap? What is the desired response? Allow new systems to simulate various forms of failures and develop mechanisms for people to maintain essential skills for debugging and maintenance. Furthermore, can university or community colleges help to bridge that gap? What is the role of different levels of education?

On the other hand, how to use AI to promote access to education? For example, affective systems for tutoring. Create learning tools that better understand student needs. How can we use AI to make depressed communities more susceptible to learning? Develop technologies to help parents be more involved in their children's education.

- *AI in the Workplace*

Conduct field work to examine how technology is impacting workers. Study the unintended consequences of technologies. What are the ramifications of deploying autonomous systems to help workers? How can workers operate efficiently in that environment? Identify the types of careers that would be attractive to populations that are at risk. Examine ways to leverage AI to level the playfield, to reduce entry barriers. Also, perform comparative analysis between countries and the way autonomous systems are being introduced.

- *Interdisciplinarity*

For computer scientists, examine solutions from the social sciences to address social illiteracy and technological humility. Design technology that enables ideas coming from the social sciences.

Theme 3: Knowledge Production (Smith-Doerr)

One important question for equitable outcomes in emerging technologies like AI is related to the scientific workforce and the kinds of organizations in which scientists work. A focus on knowledge production systems means that we need to study by whom and the process by which automation technology is produced. Understanding which organizations facilitate more or less equity for the people who are producing the knowledge is key. Who is designing emerging technologies, and for whom are they designing those technologies? How can emerging technologies be imagined in more equitable ways?

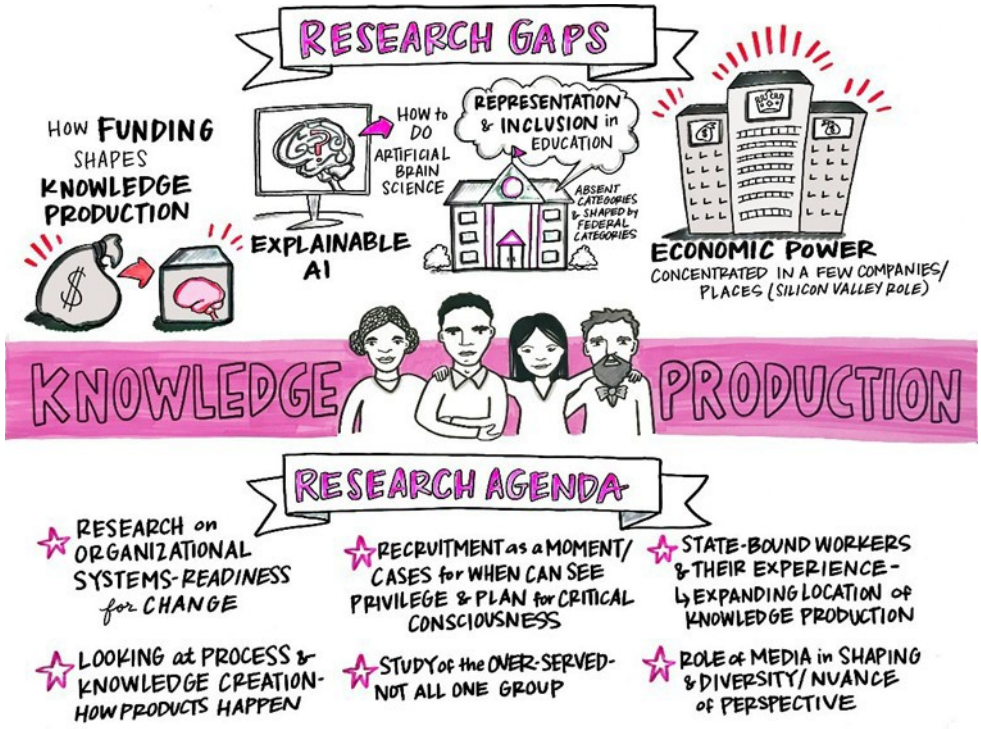

Figure 3. Graphic representation of Research Gaps and Agenda from April 2018 Workshop at PI Smith- Doerr's roundtable on "The organization of knowledge production"

Research gaps identified by academics:

- *Identification of AI knowledge producers--who are they?*

More data are needed on who is currently producing emerging technologies powered by artificial intelligence, and in what kinds of organizational locations. These data on the AI workforce are often located in private organizations, which contributes to the difficulty of closing this gap in research.

- *How does who is at the design table affect the technology?*

In order to understand how to measure the effects of demographic representation equity, more research is needed on how technologies are shaped by designers, and how their backgrounds may (or may not) shape the design process.

- *How do funding sources shape knowledge production of AI?*

Further data and analyses of how variation in funding sources (private, public, targeted or more open support) for AI research are needed.

- *Explainable AI*

Complex algorithmic systems behind artificial intelligence may be automated at a level that means human decisions are not part of the processes, making it difficult to follow how outcomes are reached. Computational brain science on AI needs to be developed in order to know how algorithms are working, and to analyze where biases and other unintended consequences may enter the system.

- *Connections between education and knowledge production*

Assumptions are often made about how STEM education systems feed into knowledge production in

firms. More empirical research on a variety of questions about the actual links between education and for-profit knowledge production systems would be enlightening. What are the limitations of interventions in education systems for how firms operate? How does data collection and the categories used to define student populations shape understanding of inclusion in learning and the tech sector?

- *Information asymmetry*

The development of AI powered technologies appears to be driven by a handful of influential corporations. Private companies are often less open to research than academic knowledge production, creating a knowledge gap. Information asymmetry occurs when private companies collect immense amounts of user data, while the users are not in turn privy to the information collected (including their own usage information).

Proposed research agenda:

- *Studying jobs held by knowledge producers and how they are changing over time*

Research on the distribution of jobs for knowledge producers will need to collect new data. This research should include the dynamic elements of how jobs change over time and shifting prestige of the occupations.

- *Who gains from automation?*

Beyond a singular focus on which groups are underserved by technologies, or those that are disproportionately being displaced from jobs by emerging technologies, it is also important to study the overserved. Research should observe who benefits and investigate variation in their organizational locations and awareness of privilege.

- *How to measure equity?*

Investigation should identify the meaningful dimensions of equity in work processes and products of AI-powered technology. Methods for measuring equity will need to be refined.

- *How to disrupt biases in technologies, in people, and organizational systems?*

Research could profitably focus on when systems are ready for change. Understanding the organizational level context of biases is an understudied area that could advance possibilities for equity.

- *Studying hiring and recruitment*

Recruitment of new hires is an organizational moment when firms articulate their ideal workers. Investigating the position of gatekeepers (like recruitment for tech firms) could provide insights into possibilities for change.

- *Understanding location of knowledge production geographically*

Decisions for placement of firms and recruiting are important to study how biases about location play into knowledge production. The class, gender and race composition of place-bound labor markets could be another way that biases enter the system.

- *Looking into how knowledge is produced organizationally*

Research on specific organizational practices for producing knowledge could yield important insights. What are the systems for developing AI, and how are algorithms reviewed and evaluated as 'good' work or not? What is the role for evaluation of biases in reviewing whether AI-powered technology works?

- *Studying the role of social media in shaping diversity of tech workforce*

Who is seen as an appropriate knowledge producer in emerging tech firms, and what role has social media played in that picture? Research could usefully analyze the polarization of media discourse and lack of nuance in gender, race, and expertise.

Theme 4: The New Spatial Mismatch (Renski)

Spatial mismatch remains relevant today, but with an ironic twist—jobs are returning to some cities at the same time that many working class families, disproportionately African American and Latinx families, are being forced out through processes of gentrification and re-segregation. If past trends continue, then the development of automation and AI will likely reinforce emerging concentrations of the most knowledge-intensive economic activities and further widen the gap between the have and have-not places. However, past trends are often poor barometers of future conditions, and the spatial impacts of automation remains an open question. To date, there has been little research that explicitly considered the spatial aspects or ramification of AI and the future of work, especially in light of its possible ramifications on societal equity. Participants focused on understanding the potential disparate impacts of new technologies on different types of communities, and how the emerging spatial distribution of job opportunities aligns with anticipated racial, ethnic and social divisions.

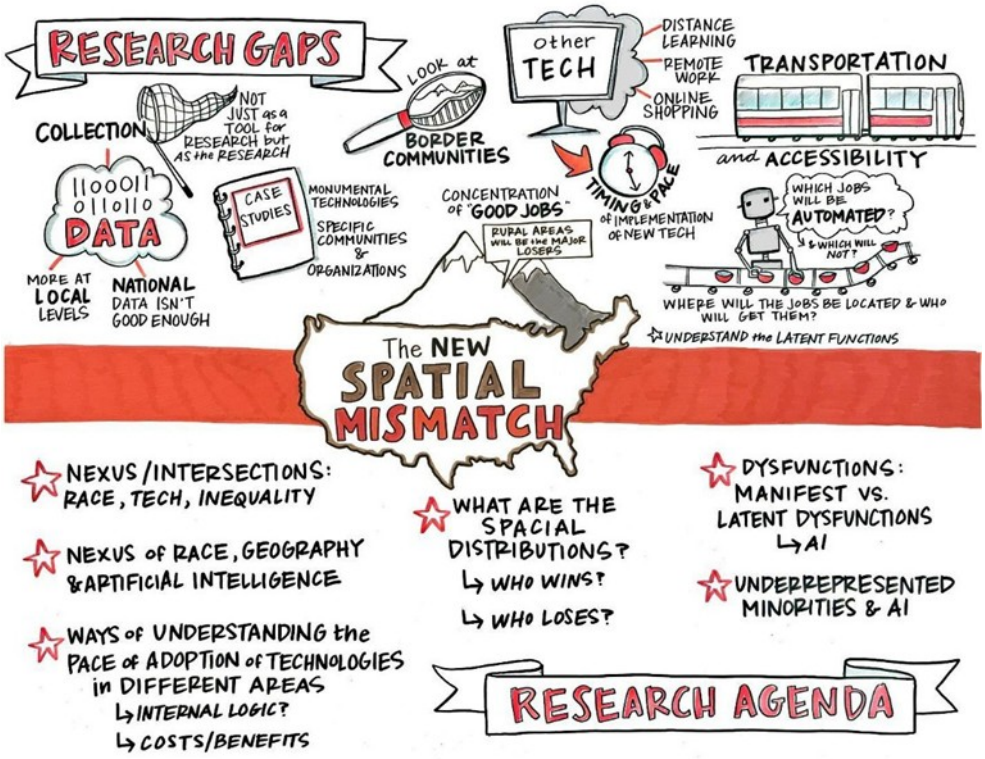

Figure 4. Graphic representation of Research Gaps and Agenda from April 2018 Workshop at PI Renski's roundtable on "The New Spatial Mismatch?

Research gaps identified by academics:

- *Intra vs. Inter-City Divisions*

Understanding inter-city differences relates to issues such as the spatial polarization of the knowledge economy, whereby some cities are winners and some are losers in the new AI- influenced landscape of jobs and income. Additionally, understanding the intra-city differences focuses on the location of those that need work and where various types of work are available within a metropolitan area. Issues of gentrification, mobility, housing and racial/ethnic segregation are most salient at this scale.

- *Better Predictive Models*

The field could benefit from more sophisticated efforts at predicting the types of jobs most at risk of elimination, as well as AI complementary jobs. Current predictions of the post-AI job market are based on studies that mainly rate occupations on the skills required on the job. AI- threatened jobs tend to be those that have more routine tasks and require less inter-personal interaction. Current studies focus mainly on jobs that are threatened by or resilient to AI. They fail to predict the types of jobs that are complementary to AI and may be in even greater demand. Nor do current models predict the development of entirely new industries or products and services that do not yet exist, and what types of skills will be needed.

- *Changes to Work Process and Organization*

Intersection of other technologies may change both the demand for and skill requirements of work. There is relatively little research on the growth of remote work and how this will influence that spatial distribution of jobs. Automation often means we end up adding work (not jobs) for some people. How does automation affect employer job requirements and change their expectations? How does shifting tasks within "surviving" occupations produce new forms of under/unpaid work?

- *Skills Mismatch*

Could the new spatial mismatch is first a skill mismatch, considering the unevenness in quality of and access to education, and the preparedness for higher education in some communities?

Proposed research agenda:

- *New data sources and data tools*

Better and more data sources on employment and skills by detailed occupations and industries at fine granular spatial scales (city and neighborhood). New data sources (e.g., scrapped and aggregated job postings) offer promise, but are proprietary, expensive, and are not transparent regarding data collection methods or representativeness.

- *Interrelationship between job availability and transportation options*

Old notions of spatial mismatch are still relevant. Are there particular locals within metropolitan areas where jobs are more likely to be created or eliminated? How does this match residential housing patterns of those most in need of work?

- *Examine trends within specific industries:*

For instance, universities are growing for jobs requiring higher skill levels. However, many of the service jobs may be replaced. A study could examine the hiring of university staff and how technology is going to change the need for staff. It is an "undercooked" idea.

- *Spatial variations in the adoption of AI technology*

There is an assumption that technology becomes spatially ubiquitous once developed. Are there ways of understanding the pace of adoption of technologies in different areas?

- *Education and Training*

More research is needed that considers different modes of education and training, and whether this might be a more effective route to upskilling and or retraining minorities and other AI- threatened populations.

Theme 5: Driving and Automation (Roberts)

Automated driving systems (ADSs) will change the way Americans approach driving and transportation. ADSs offer great promise in terms of reducing traffic fatalities and associated healthcare costs. They are being developed at a rapid pace by technology companies as well as vehicle manufacturers and are being pilot tested on our roads. At the same time, there are other stakeholders who have a vested interest in the development and deployment of ADSs, such as everyday drivers, professional drivers, vehicle maintenance specialists, insurance companies, and local governments. With all of the disparate stakeholder viewpoints, how ADSs will impact jobs and affect certain races disproportionately is often not a point of discussion. Additionally, we need to consider the secondary impacts of this new technology and how we can best prepare our transportation workforce for such a transformational shift.

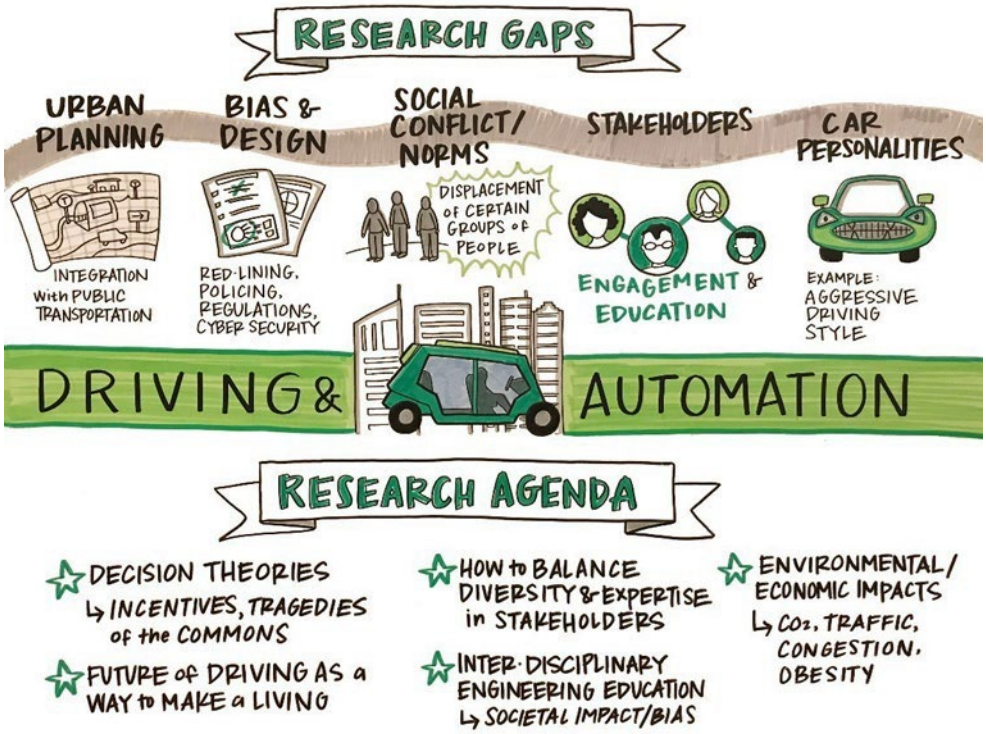

Figure 5: Graphic representation of Research Gaps and Agenda from April 2018 Workshop at roundtable on "Driving and Automation"

Research gaps identified by academics:

- *Urban planning*

ADSs need to be integrated with public transportation, a service that is predominantly used by racial minorities, and traffic flow designers need to redesign roadways such that ADSs can function efficiently.

- *Bias in design*

It has been well documented that: current ADSs rely on technology that does not accurately detect people of color, ADSs are not affordable, and ADSs require substantial infrastructure that is often missing in low-income neighborhoods. In light of these natural biases in the design of ADSs, an important question to answer is whether ADSs will harm racial minorities more so than the majority.

- *Social conflicts and norms*

Driving is an activity with implicit and explicit social norms. With the introduction of ADSs, the social norm will change such that those who do not have access to ADSs are ostracized. For example, ADSs may be used in different ways than typical vehicles (e.g., people may rent their ADSs to others when not in use), thereby creating a new economy that only a certain group of people can access. It is important to consider who benefits and who loses with these new social norms.

- *Stakeholders*

Various stakeholders are not included in the design, development, or deployment of ADSs. For example, professional truck drivers are seeing incremental changes in their job role as more automation is introduced into the cab. However, they are not always trained on the use of the technology. Academics were interested in understanding how workers could transfer skills to find new employment and how workers would support their family within the new ADSs society.

- *Car personalities*

The development of ADSs by different manufacturers will undoubtedly lead to different vehicle personalities (e.g., Mercedes Benz once stated that they would design their vehicles such that the vehicle occupants are always saved in a crash, versus pedestrians or bicyclists). Such freedom in the design of ADSs needs to be checked with a government agency to ensure that safety of all road users remains paramount.

Proposed research agenda:

- *Decision Theories*

We need to develop decision theories and incentives with respect to designing ADSs. These theories would rely on currently available data as well as modeling and simulation techniques that describe a high- level picture of the future of ADSs. Such theories would also aid in designing interventions such that the benefits and effects of ADSs are evenly distributed.

- *Driving and Work*

For those who rely on driving as a form of income, we need to understand how they can still earn an income and relatedly, how professional drivers can be trained for a new career.

- *Stakeholders*

There are many stakeholders who are interested in and will be affected by the introduction of ADSs. We need to incorporate all of the disparate stakeholder viewpoints while balancing expertise and diversity.

- *Ethics of ADSs*

We need to develop a new paradigm about how we educate engineers and computer scientists who develop ADSs to ensure they are aware of the ethical impact of their decisions.

- *Environmental and Economic Impacts*

It has been well documented that ADSs will have a positive impact on traffic safety. However, we also need to consider the secondary and tertiary effects of ADSs, such as its effect on agriculture, safety, families, and the environment.

Regional Stakeholder Workshop (June 2018)

The third workshop focused on current efforts regional stakeholders were involved in that addressed the issue of automation, work, and racial equity, as well as what regional stakeholders would like to see in terms of research. Across each theme, stakeholders expressed:

- *Location biases*

Stakeholders called for more attention in academic research to overcoming biases and inequities by location, citing the lack of placement of firms and recruitment of populations outside of large booming cities.

- *Supply-side issues and educational inequalities*

Concerns were raised about career mobility by class and overcoming systematic educational inequalities. Research addressing ways to make education and training opportunities a more level playing field would increase the diversity and size of the labor supply for high tech jobs in emerging technology firms. Many regional stakeholders were involved in or knew of programs that focused on training people on skills that are needed in this new automated landscape.

Though useful, many questioned the utility of such training given the fast pace at which technology changes; teaching the art of lateral movement is a means to prevent one's skills from becoming antiquated.

- *Demand-side issues*

From a tech industry demand perspective, firms are interested in the continued development of machine learning methods to match jobs in demand with labor pools. Research on life-long learning and effective career transitions for workers to train for new jobs was also of interest. Regional stakeholders would like to see research that quantified which jobs would be eliminated and which jobs would be created because of automation. With such data, they could predict how to retrain workers or teach them new skills, potentially using online courses or MOOCs. In this transition phase (i.e., between an employee losing their job because of automation and the employee getting a new job), regional stakeholders wanted to know how they (and the government) could best support their employees to ensure that people are not out of work.

- *Values issues*

From a community perspective, stakeholders expressed the desire to see research that better connects emergent technologies to people's daily lives. Academic research and calls for new research should represent the perspectives, values, and concerns of the public–and that public engagement should be part of the design process in the research and development of emerging technologies. Lastly, the regional stakeholders wanted more information about how racial minorities feel about automation and its impact on their work.

- *Expertise issues*

From a public service perspective, there was a desire for research that would illuminate how to get beyond standardized approaches to knowledge and recruitment (i.e., standardized testing) in government service. Stakeholders called for research that would help with identifying other kinds of expertise and methods of valuing diversity in hiring (e.g., in hiring a police force).

- *Financing issues*

Stakeholders expressed concern about lack of diversity in funding for emerging technologies. Research addressing racial biases in funding was thought to be particularly important given the lack of diversity among venture capitalists, which then may lead to the replication of existing inequalities in emerging tech firms. Stakeholders called for evaluation studies of the effects of implicit bias training for funding decision-makers, for example in government programs that use public money to support the development of new technology firms.

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Appendix A: Agenda for April 2018 workshop

Understanding Emerging Technologies, Racial Equity, and the Future of Work

Thursday, April 5, 2018

3:00 PM Registration for Workshop participants opens in room 170, John W. Olver Design Building (551 N. Pleasant St.)

3:30-4:00 PM Opening Reception (Open to the Public). Location: Design Blding, rm 170

4:00-5:30 PM Open Plenary: Moshe Vardi (Rice University) and Anna Branch (UMass). Location: Olver Design Building Atrium

6:00-8:00 PM Dinner for Workshop participants. Location: Bistro 163, 63 N. Pleasant St., Amherst.

Friday, April 6, 2018
(Location: Campus Center, Amherst Room, 10th floor)

8:30 Breakfast available

9:00 AM Introduction and Setting the Workshop Agenda (Organizers)

9:15-10:00 Organizers Opening Remarks

- Anna Branch, "Intersectionality of Race, Gender, and Skill: Historical labor market vulnerability and who gets replaced when technology advances"
- Shlomo Zilberstein, "The impact of AI and robotics on the futureof work: Using AI to empower and enable participation in the job market"
- Henry Renski, "The New Spatial Mismatch: Examining the intersecting geographies of industry, skill, and race in an AI-transformed economy"
- Laurel Smith-Doerr, "The organization of knowledge production: Who designs emerging technologies and how can they be imagined in equitable ways?"

- Shannon Roberts, “Driving and Automation: Stakeholder interests and how automated vehicles will change the driving landscape”

10:00-10:30 AM Coffee Break

10:30-12:00 PM Interactive Roundtables to Identify Research Gaps (see Breakout list)

- Yellow table--AI and the future of work (Shlomo Zilberstein)
- Blue table--Knowledge production (Laurel Smith-Doerr)
- Green table--Driving and Automation (Shannon Roberts)
- Pink table--Intersectionality of Race, Gender, and Skill (Anna Branch)
- Purple table--The New Spatial Mismatch (Henry Renski)

12:00-1:00 PM Buffet Lunch (Amherst Room)
Speaker: Ruha Benjamin (Princeton University),“Captivating Technology: Reimagining Race, Innovation, and Equity in Everyday Life”

1:00-2:15 PM Research Agenda Setting (at breakout roundtables)

2:15-3:00 PM Developing Stakeholder Engagement (at breakoutroundtables)

3:00-3:30 PM Coffee Break

3:30-4:30 PM Report back by roundtable groups and Graphic Facilitation

4:30-5:00 PM Closing Plenary—Organizers discuss next steps

5:00PM Workshop Adjourns

Appendix B: Agenda for June Stakeholders Workshop

June 18, 2018

9:00 AM Continental Breakfast available, Poster viewing

9:15 AM Welcome and Introduction to Workshop: Laurel Smith-Doerr, Director of the Institute for Social Science Research, and Enobong (Anna) Branch, Associate Chancellor for Diversity and Equity

9:30-10:00 AM Keynote: Victor Woolridge, UMass Boardof Trustees

10:00-11:30 AM Interactive Roundtable Discussion--Stakeholder Experiences/Concerns/Needs

- Intersectionality of Race, Gender, and Skill in Labor markets (Anna Branch)
- Using AI to empower participation in the job market (ShlomoZilberstein)
- Spatial Mismatch: Geographies of industry, skill, and race (HenryRenski)
- Knowledge production: Who designs emerging tech (LaurelSmith-Doerr)
- Driving and Automation: The changing driving landscape (Shannon Roberts)

11:30-12:00 PM Presentation of Academic Workshop Posters/Research Agenda

12:00-1:00 PM Lunch/Closing Discussion for feedback on Research Agenda/Next steps

1:00 PM Adjourn

Appendix C: University of Massachusetts Faculty Participants at March 2018 workshop

Name	Department
Adrion, Rick	Information and Computer Science
Baker, Erin	College of Engineering
Branch, Anna	Office of Equity & Inclusion; Sociology
Brun, Yuriy	Information and Computer Science
Francis, Dania	Economics, Afro-American Studies
Ganguli, Ina	Economics
Gano, Gretchen	Institute for Social Science Research
Gerstel, Naomi	Sociology
Gonzales, Eric	Civil & Environmental Engineering
Harper, Krista	Anthropology
Jensen, David	Information and Computer Science
Krishnamurty, Sundar	Mechanical & Industrial Engineering
Meliou, Alexandra	Information and Computer Science
O'Connor, Brendan	Information and Computer Science
Perry-Jenkins, Maureen	Psychological & Brain Science
Rattigan, Matt	Information and Computer Science
Renski, Henry	Landscape Architecture And Regional Planning
Roberts, Shannon	Mechanical & Industrial Engineering
Smith-Doerr, Laurel	Institute for Social Science Research; Sociology
Sturdevant Rees, Paula	College of Engineering
Tomaskovic -Devey, Donald	Sociology
Young, Kevin	Political Science
Zilberstein, Shlomo	Information and Computer Science

Appendix D: Participants at April 2018 workshop

Name	Institution	Affiliation
Ifeoma Ajunwa	Cornell University	Industrial and Labor Relations School
Sharmistha Bagchi-Sen	University at Buffalo-SUNY	Department of Geography
Ruha Benjamin	Princeton University	Sociology and African American Studies
Margrit Betke	Boston University	Department of Computer Science; The Image and Computing Group
Anna Branch	University of Massachusetts, Amherst	Office of Equity & Inclusion; Department of Sociology
Joel Branch	Lucd	Lucd
Carla Brodley	Northeastern University	Khoury College of Computer Sciences
Vincent Conitzer	Duke University	Computer Science;Economics;Philosophy
Haydee Cuevas	Embry-Riddle Aeronautical University	School of Graduate Studies; Human Factors and Ergonomics Society
Cedric De Leon	University of Massachusetts, Amherst	Department of Sociology
Tawanna Dillahunt	University of Michigan	School of Information; Electrical Engineering and Computing Science Department
Rayvon Fouché	Purdue University	School of Interdisciplinary Studies
Jason Garvey	University of Vermont	Department of Leadership and Developmental Sciences

Juan Gilbert	University of Florida	Computer and Information Science and Engineering; Human-Experience Research Lab
Michael Goodman	University of Massachusetts Dartmouth	Public Policy; Public Policy Center
Darrick Hamilton	The Ohio State University	Glenn College of Public Affairs; Departments of Economics and Sociology; Kirwan Institute for the Study of Race and Ethnicity
Sneha Veeragoudar Harrell	Massachusetts Institute of Technology	School of Humanities, Arts, and Social Sciences
Kaye Husbands Fealing	Georgia Institute of Technology	School of Public Policy
Charles Isbell	Georgia Institute of Technology	School of Interactive Computing; GVU Center+ Institute of Robotics and Intelligent Machines
Kelly Joyce	Drexel University	Center for Science Technology and Society; Department of Sociology
Nancey Green Leigh	Georgia Institute of Technology	School of City and Regional Planning; College of Design
Edward Malecki	Ohio State University	Department of Geography
Edward Moore	Central Connecticut State University	Department of Engineering
Alondra Nelson	Columbia University	Department of Sociology; Social Science Research Council
Deborah Nightingale	University of Central Florida	Department of Industrial Engineering and Management Systems
Maria (Mia) Ong	TERC	TERC
Jason Owen-Smith	University of Michigan	Barger Leadership Institute; Institute for Research on Innovation and Science
Marie Paretti	Virginia Tech	Virginia Tech Engineering Communication Center
Henry Renski	University of Massachusetts Amherst	Landscape Architecture & Regional Planning; Institute for Social Science Research

Renata A. Revelo	University of Illinois at Chicago	UIC Dept. of Electrical & Computer Engineering
Shannon Roberts	University of Massachusetts, Amherst	Mechanical & Industrial Engineering Department
Susan Roberts	Worchester Polytechnic Institute	Chemical Engineering Department; Biology and Biotechnology Department; Biomedical Engineering Department
Laurel Smith-Doerr	University of Massachusetts Amherst	Department of Sociology; Institute for Social Science Research
Anna Swan	Boston University	Department of Electrical and Computer Engineering; BU Photonics Center
Moshe Vardi	Rice University	Computer Science Department; The Ken Kennedy Institute for Information Technology
Langdon Winner	Rensselaer Polytechnic Institute	Science and Technology Studies
Shlomo Zilberstein	University of Massachusetts Amherst	Resource Bounded Reasoning Lab; Information and Computer Science

Appendix E: Participants at Stakeholder Workshop, June 2018

Name	Affiliation
Thomas Fitzgerald	Mass State Police
Trinh Nguyen	Mayor's Office of Workforce Development
Katie Stebbins	UMass President Office
Ryan Wallace	University of Southern Maine, Center for Business and Economic Research
Matthew Poirer	USDOT-FMCSA
Joseph McLaughlin	Boston PIC
Raija Vaisanen	Commonwealth Corporation
Sandra Kogan	IBM
Anika Van Eaton	Boston Private Industry Council
Mareshia Donald	AWIS
Karen Yee	AWIS
Ted Landsmark	Dukakis Ctr Northeastern University
David Sittenfield	Museum of Science
Nancy Taylor	Old South Church in Boston
Angela Johnson	Transportation for Massachusetts
Manish Gaurav	Burning Glass Technologies
Anjali Sakaria	Boston Federal Reserve
Victor Woolridge	UMass Housing Authority
Anmol Chaddha	Boston Federal Reserve
Greg Bunn	Executive Office Labor and Workforce Development

Appendix F: Participants' Recommended References

Web Resources

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https://futureoflife.org/wp-content/uploads/2017/01/Jeffrey-Sachs.pdf

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