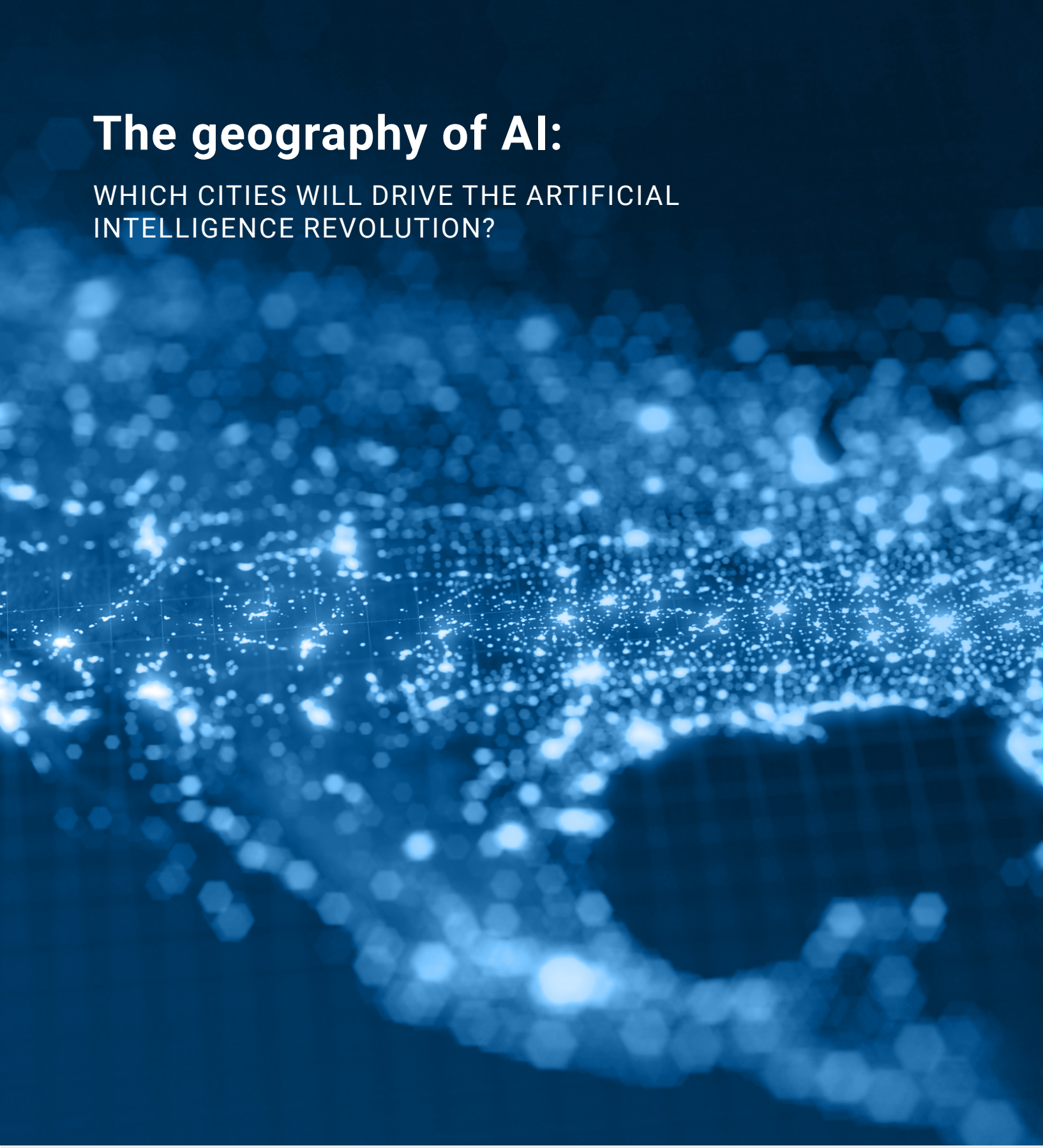
The geography of AI:

WHICH CITIES WILL DRIVE THE ARTIFICIAL INTELLIGENCE REVOLUTION?



Metropolitan Policy Program at BROOKINGS

Mark Muro and Sifan Liu

SEPTEMBER 2021

Contents

Executive summary

As the post-pandemic economic era nears, much of the U.S. artificial intelligence (AI) discussion revolves around futuristic dreams of both utopia and dystopia, with promises ranging from solutions to global climate change on the positive side to a "robot apocalypse" on the negative. However, it bears remembering that AI is also becoming a real-world economic fact, with major implications for national and regional economic development.

Based on advanced uses of statistics, algorithms, and fast computer processing, AI has become a focal point of U.S. innovation debates. Even more, AI is increasingly viewed as one of the next great "general purpose technologies"—one that has the power to transform sector after sector of the entire economy.

All of which is why state and city leaders are increasingly assessing AI for its potential to spur economic growth. Such leaders are analyzing where their regions stand and what they need to do to ensure their locations are not left behind.

In response to such questions, this analysis examines the extent, location, and concentration of AI technology creation and business activity in U.S. metropolitan areas.

Employing seven basic measures of AI capacity, the report benchmarks regions on the basis of their core AI assets and capabilities as they relate to two basic dimensions: AI research and AI commercialization. In doing so, the assessment categorizes metro areas into five tiers of regional AI involvement and extracts four main findings reflecting that involvement.

Overall, the report finds that:

- The U.S. AI industry is growing rapidly, but is still emergent and relatively limited in scope.
- AI activity is highly concentrated in a short list of "superstar" metro areas and "early adopter" hubs, often arrayed along the coasts.
- Numerous research and contracting centers owe their standing to federal R&D flowing into major universities.
- Nearly 90 additional communities are potential centers of future AI growth, especially where large national or global firms are driving adoption.

In discussing these findings, the report points to genuine opportunities for some metropolitan areas as well as cautions.

On the upside, AI is a powerful force that is growing rapidly and could increase the productivity of virtually all regional economies. Therefore, as leaders seek to position their locales for post-pandemic vitality, AI can and should be part of the discussion.

At the same time, the information in this report suggests that the task of developing a significant AI cluster will be challenging. Wide variations in cities' starting points, research sectors, and business activities require that locations assess their positioning and capabilities clearly. The "winner-take-most" dynamics of digital and platform economies also counsel caution, as they suggest that relatively few places could drive the bulk of early-stage AI-related development.

Given that, the analysis concludes by reviewing a series of initial strategy considerations keyed to each of the AI city types identified in the report. These priorities range from centering local AI ecosystems on ethical use to promoting AI adoption among local firms to addressing the need for diverse talent. The information and assessments in this report underscore the need not for all metro areas to spring into action right now, but rather to assess their positioning and then consider acting.

Introduction

Much of the artificial intelligence (AI) discussion in the U.S. revolves around futuristic dreams of both utopia and dystopia. From extreme to extreme, AI's promises range from solutions to global climate change on the positive side to a "robot apocalypse" on the negative.

However, it bears remembering that AI is also becoming a real-world economic fact, with implications for national and regional economic development.

Based on advanced uses of statistics, algorithms, and fast computer processing, AI has become a focal point of innovation. Already, AI is viewed as one of the next great "general purpose technologies"—one that has the power to transform sector after sector of the entire economy. Accordingly, the pending $250 billion federal Innovation and Competition Act of 2021—with its sizable research and development flows and regional technology hubs focused on AI and related technologies—defines AI as a "key technology" critical to national security, economic competitiveness, and national growth.

All of which is why state and city leaders are increasingly assessing AI's potential to spur economic growth in their regional economies.

Metropolitan areas as diverse as Central Indiana, San Diego, and Louisville, Ky. have sought region-specific AI evaluations in the last two years.[1] Numerous states have identified AI as a regional economic development priority.[2] And at least six state legislatures considered legislation to create task forces or commissions on AI economic development in 2021.[3] In short, more states and regions are assessing where they stand on AI and asking what they need to do to ensure they are not left behind in the emerging AI economy.

In response to such questions, this analysis examines the location and concentration of AI technology creation and business activity in U.S. metropolitan areas in the last few years. To that end, the report offers a systematic early look at the emerging geography of AI in America as determined by two basic dimensions: AI research and AI commercialization. Focusing on seven basic measures of AI capacity arrayed across the two dimensions, the assessment categorizes the nation's metro areas into five tiers of regional AI involvement, ranging from "superstars" (California's Bay Area) to regions with no AI activity to speak of. In doing that, the report benchmarks regions on the basis of their core AI assets and capabilities as they stand now.

As such, the report reveals sharp variations in the amount and nature of AI activity transpiring in U.S. metropolitan areas—and with them, sharp variations in regions' AI-related economic development prospects as well.

AI's national and regional economic potential

To consider the geography of the AI sector, it is first important to agree about what AI is, why it is important economically, and why geography may be an important feature of its growth.

WHAT IS AI?

AI for present purposes is a summary term—absent a standard definition—for a wide range of digital systems that can sense their environment and learn, think, predict, and draw inferences about the world in accordance with what they're sensing.

Such systems, according to Shubhendu and Vijay, combine sophisticated hardware and software with elaborate databases and knowledge-based processing models to "demonstrate characteristics of effective human decision making."[4]

In similar fashion, the Microsoft monograph *The Future Computed* defines AI as "a set of technologies that enable computers to perceive, learn, reason, and assist in decision-making to solve problems in ways that are similar to what people do."[5]

In any event, AI systems are realizing myriad applications increasingly prevalent in people's daily lives: effective recommendation engines, mistake-free voice recognition, cutting-edge image recognition, enhanced medical diagnoses, vehicle autonomy, and more.

And AI is already ubiquitous. On the consumer side, media streaming and e-commerce platforms such as Netflix, Spotify, and Amazon rely heavily on AI-powered recommendation systems, while customer service queries have long since become the province of AI-managed chatbots. Likewise, when a Tesla roadster goes "hands-free" on the highway, that is AI.

Equally pertinent for business, AI is currently being applied to enhance a wide range of health care services, from pattern recognition and scan reading to diagnosis and drug discovery. Likewise, AI is being used to enhance fraud detection in the finance sector, manage the movements of robots in warehouses, and support predictive maintenance of critical industrial equipment in the manufacturing sector.

AI'S POTENTIAL FOR THE ECONOMY

Not surprisingly, such advances have generated excitement among economic development practitioners. To be sure, concerns persist that AI will lead to mass automation and job losses through its introduction of human-level capabilities. AI applications promise both task augmentation and task automation, and research shows that while the former leads to new task creation that expands employment, the latter displaces labor and does not improve labor productivity.[6] Relatedly, social and technology thinkers argue that if society doesn't harness the technology responsibly and share its benefits equitably, AI will lead to "greater concentrations of wealth and power for the elite few who usher in the new age—and poverty and powerlessness...for the global majority."[7]

And yet, the economic opportunity appears compelling as the nation looks beyond the COVID-19 pandemic into the next decade. Already, AI applications are increasingly being utilized in a range of industry sectors, from health care, finance, and information technology to consumer sales, marketing, transportation and fulfillment, and national security.[8]

Beyond that, AI is forecasted to become the technology source of substantial economic growth and whole new industries. Most notably, the nature and broad applicability of AI's emerging capabilities ensure that it has the potential to diffuse significant productivity gains widely through the economy, with potentially significant impacts.

On the productivity front, AI's capacity to reduce the time and cost required to conduct basic business functions such as detection, classification, management, learning, and planning could yield substantial efficiencies to firms. Accordingly, estimates by PricewaterhouseCoopers, McKinsey & Company, and Analysis Group (funded by Facebook) foresee large gains in quality and productivity for companies.[9] PricewaterhouseCoopers has flagged AI's possible $3.7 trillion contribution to GDP in North America by 2030.

More broadly, the wide applicability of AI to myriad business uses makes the technology relevant to multiple domains of the economy. That's why many economists and business scholars believe that AI has the potential to be "the most important general-purpose technology of our era," as Brynjolfsson and McAfee assert.[10] In this vein, Athey notes that the "general purpose" nature of machine learning, for instance, is highly complementary with such gigantic, crosscutting trends as digitalization, cloud computing, and open source software, ensuring that AI applications will spread their productivity assistance widely.[11]

Such breadth of relevance, ease of integration, and—therefore—scalability suggest the potential for wide-ranging positive economic impacts. This has led to hopes that AI—with proper management—could help improve the nation's standard of living over time.

AI'S POTENTIAL FOR REGIONAL ECONOMIES

And now state and regional leaders are also getting interested in AI—and rightly so, given that general purpose technologies (and especially digital ones) tend to have considerable local impacts and can apply a distinctive imprint to the nation's economic geography.

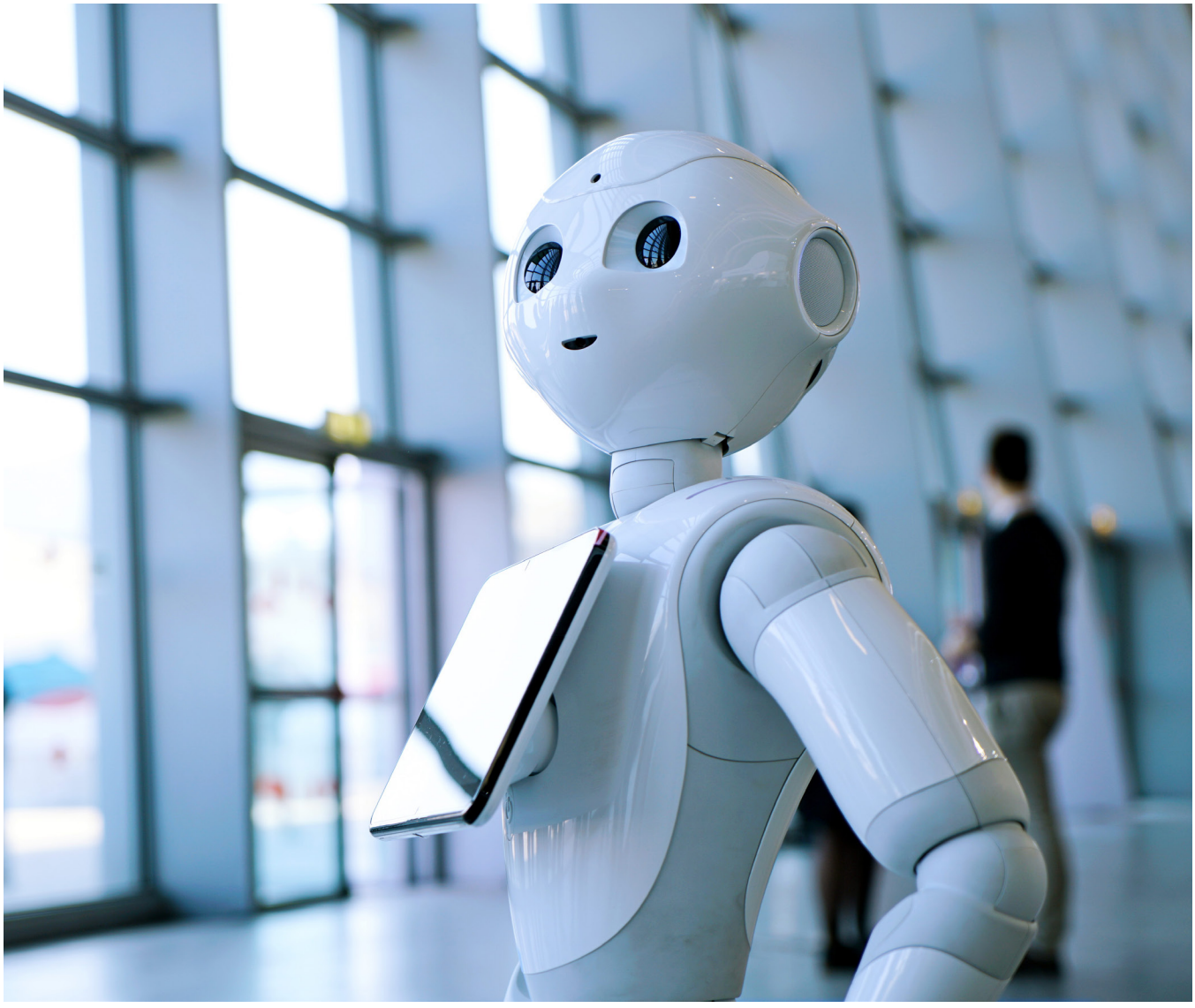
On this front, it bears noting that recent waves of technology innovation and adoption have massively altered the nation's economic landscape, upping the urgency of economic development efforts. Most notably, waves of digital technology adoption—characterized by firm and region first-mover advantage, agglomeration economies, and "platform" effects—have raised the stakes for economic development practitioners. First-mover status among software development hubs, for instance, has led to the rise of "superstar cities" such as Seattle and the Bay Area, generating extreme market concentration and stark interregional gaps.[12] At the same time, the rise and maturation of new technologies also raises the possibility over time of tech sector diffusion from early superstar cities into more regions.

In this fashion, the rise of AI holds out the possibility of both major gains for a few places and more broadly dispersed opportunity for many metro areas—but the exact future is uncertain.

On one hand, the earliest stages of technology development are often spatially concentrated near the site of key innovations, given their dependence on co-located human networks exchanging "sticky information."[13] On the other hand, later phases of adoption and commercialization are frequently more dispersed, as earlier-stage innovation gives way to more "codified" adoption.[14]

Given that, the ongoing development of the U.S. AI industry offers multiple possible scenarios for local economic development leaders, and challenges them with multiple questions. To the extent the industry is at all maturing, it offers the possibility of local economic development in multiple metropolitan areas. To the extent that industry is extremely nascent, such broader benefits for numerous metro areas may be farther in the future, and the immediate rewards extremely concentrated in just a few places.

Considering these competing scenarios, a data-driven snapshot of the industry's current geography may help inform regional leaders across the country as they assess the AI opportunity at a critical moment.



Approach

This report aims to provide a systematic assessment of the location and intensity of AI activities in the nation's major metropolitan areas. Using data collected on various aspects of AI assets and capabilities at the metro area level, the assessment deploys cluster analysis to reveal the key metropolitan areas in the current AI landscape; their particular activity mixes; and the metro areas' particular involvement in those activities.

DATA

To analyze metropolitan areas' varying AI profiles, the following analysis looks across indicators that measure 1) **research** activities that advance the science of AI; and 2) **commercialization** activities that develop new AI solutions for specific business functions.

- **Research measures** include indicators that depict AI science and research and development activities, and report metropolitan areas' federal research and development grants and contracts in AI-related projects, their regions' publications at top AI conferences, and their AI patents. Note that while AI patents appear to forecast industrial applications of AI technologies, patents usually reflect early-stage activity without a clear path to commercialization.
- **Commercialization indicators** measure AI commercialization activities and include the number of innovative companies there that create AI solutions for industries, counts of AI-related job postings that signal where AI-skilled workers are being hired to implement AI products, and counts of job profiles with AI skills that reflect AI talent supply in the region.

CLUSTER ANALYSIS

With this data assembled, per capita measures of the seven AI indicators are used to conduct a cluster analysis. We applied a k-means method—an algorithm that groups similar data points into clusters—to 384 metro areas across the seven indicators.

Five clusters emerged from the analysis:

- The California **Bay Area** superstar region, comprised of the San Francisco and San Jose metropolitan areas
- **Early adopters** (13 metro areas with above-average activities across all metrics)
- **Research and contracting centers** (21 metro areas with substantial federal funding)
- **Potential adoption centers** (87 metro areas that have some, but below-average, AI activities)
- The remaining 261 **other metro areas** that do not support any significant AI activities

Please see the appendix for a full description of the data source and detailed methodology.

Table 1. Indicators and data source

Dimension	Indicators	Source
Research	Federal R&D grants to universities on AI projects	STAR METRICS
	Federal AI R&D contract spending to private firms	Stanford HAI
	Academic paper at top AI conferences	NeurIPS, ICML
	AI-related patents	USPTO
Commercialization	Companies providing AI solutions	Crunchbase
	Job postings require AI skills	Emsi
	Job profiles with AI skills	Emsi

Findings

FINDING 1: ALTHOUGH GROWING RAPIDLY, THE AI INDUSTRY IS STILL EMERGENT AND RELATIVELY LIMITED IN SCOPE.

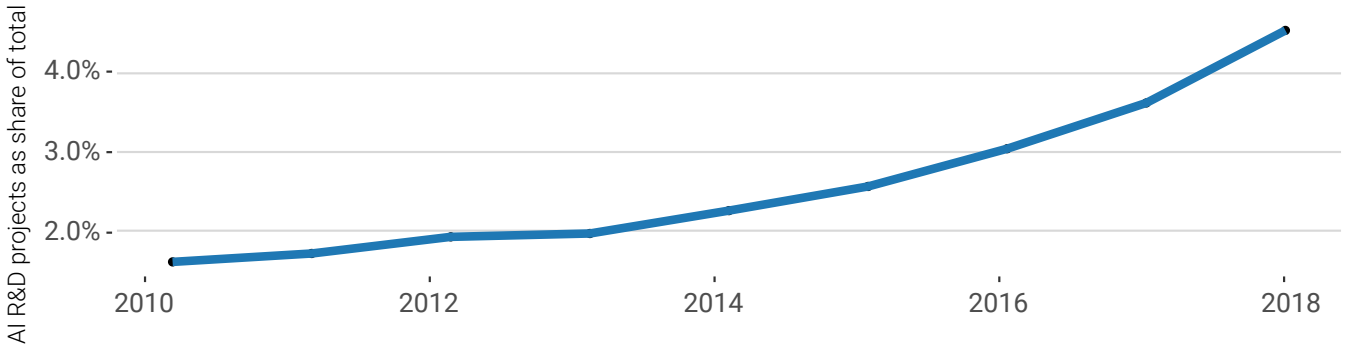
The U.S. AI enterprise is both fast-growing and still a relatively small sector of the economy, according to the research and commercialization indicators analyzed here.

To be sure, important AI research dates back to the 1950s, and is growing exponentially—to the point that federal research and development expenditures at U.S. colleges and universities grew by 45% in the past decade. However, in 2018, the total federal expenditures on AI research and development at U.S. colleges and universities accounted for about $2 billion, out of total U.S. spending of nearly $40 billion on all topics. As such, federally funded AI projects in U.S. colleges and universities encompassed just 5% of total federal research and development expenditures at U.S. colleges in that year (Chart 1).

Additional tracking of peer-reviewed AI scientific publications from Stanford University's Institute for Human-Centered Artificial Intelligence (HAI) finds similar trends. According to HAI's 2021 AI Index Report, the number of peer-reviewed AI publications grew 12-fold from 2000, reaching more than 120,000 in 2019. However, that growth still only accounts for 3.8% of all peer-reviewed publications.[15]

Figure 1. Federally funded AI projects have grown, but their overall share remains low

Share of AI–related projects in Federal R&D expenditure at U.S. colleges and universities



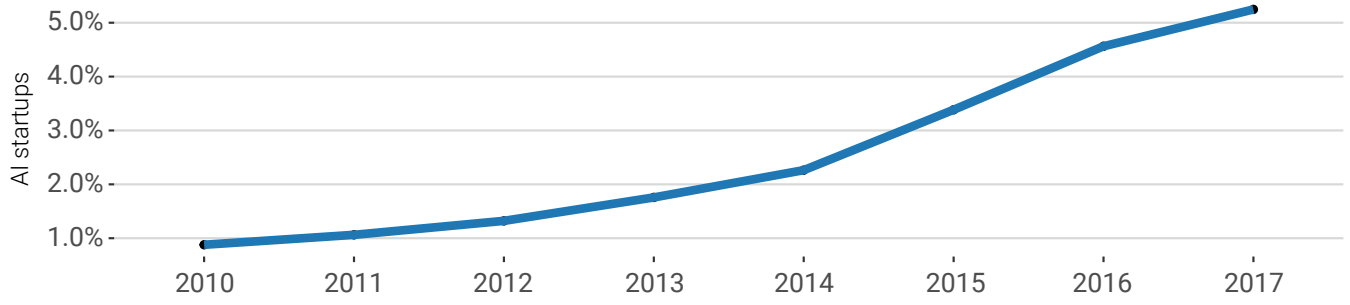
Source: Brookings analysis of STAR METRICS data.

AI commercialization follows similar patterns. Newly founded firms that provide AI solutions have been proliferating rapidly in the last decade, according to an analysis of data from Crunchbase, a platform that tracks technology-based startups. But even at this innovation frontier, AI startups account for merely 5% of new technology firms each year in the U.S., after steady growth from less than 1% 10 years ago (Chart 2).

The increasing demand for AI talent reflects the growing adoption of AI capabilities both by startups and more broadly by industry. Here, too, fast growth comes from a small base. According to data from Burning Glass Technologies, an analytics software company, AI job postings as a share of all job postings quadruped in the past decade. However, those job additions still account for a tiny fraction in the U.S. labor market. In 2019, there were about 160,000 AI job postings in the United States, which was less than 10% of the 2 million total IT job postings, and only 0.7% of all job postings (Chart 3).[16] Despite the excitement around accelerated AI adoption since the COVID-19 pandemic disrupted the business world, both the total number of AI jobs and the share of AI job postings experienced a slight decline in 2020.[17]

Figure 2. AI commercialization is on the rise

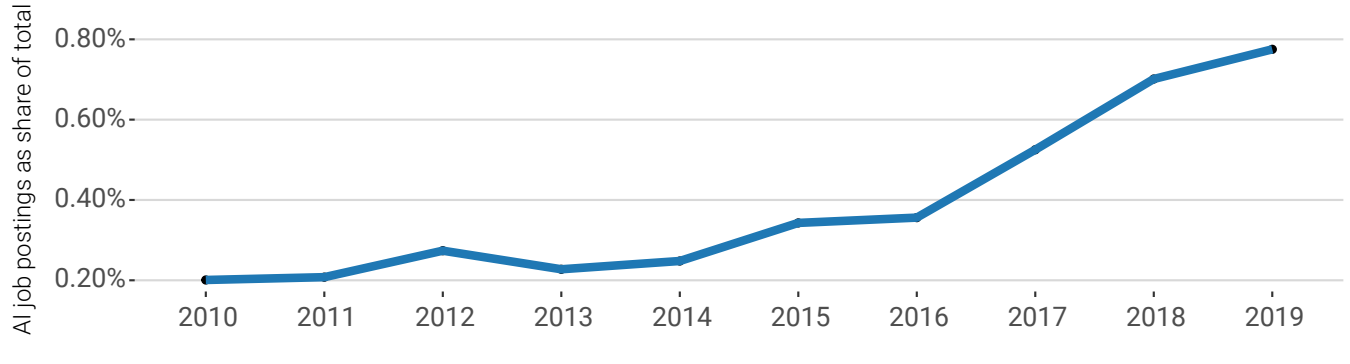
Firms providing AI solutions as share of all tech companies



Source: Brookings analysis of Crunchbase data.

Figure 3A. AI job postings saw accelerated growth

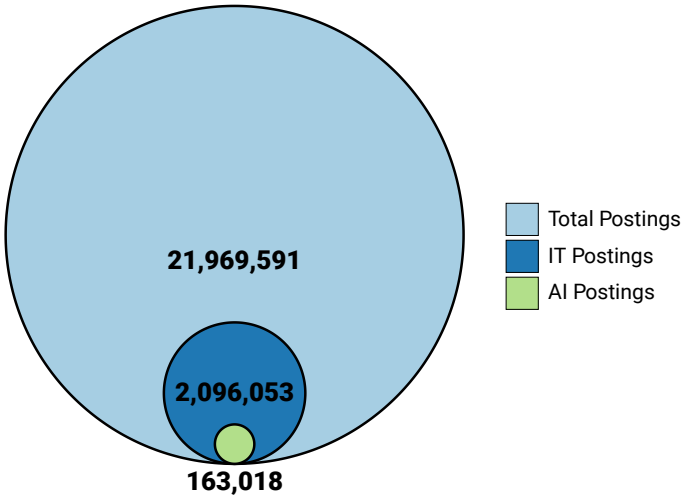
Job postings with AI skills as share of all job postings



Source: Brookings analysis of Burning Glass data, available from Stanford HAI 2021 AI Index Report public data.

Figure 3B. Job postings requiring AI skills account for less than 1% of all job postings

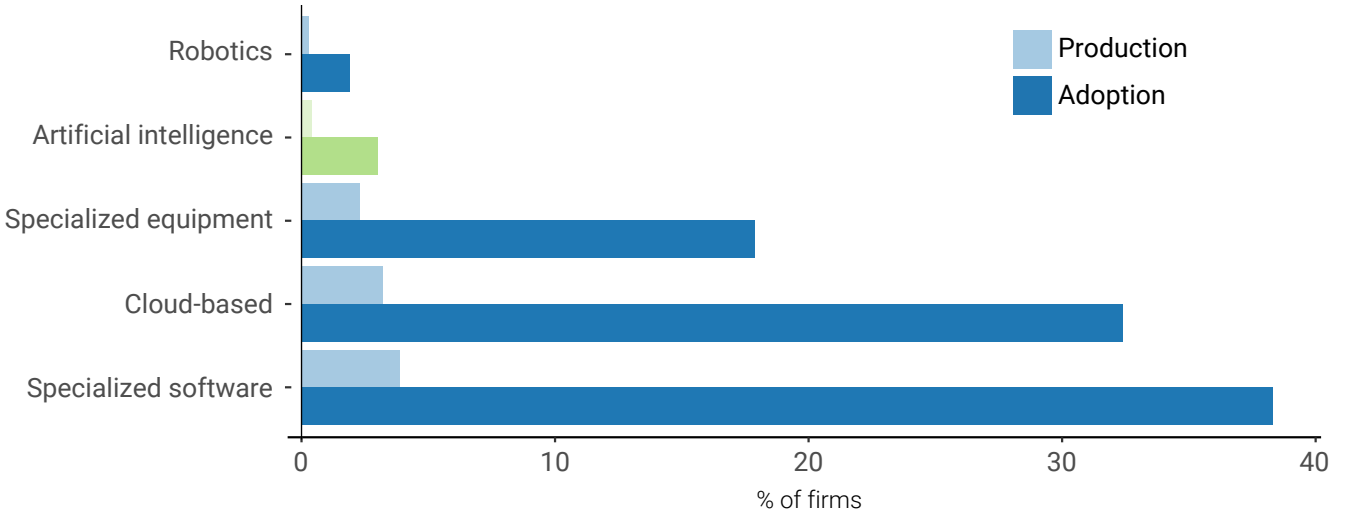
Number of total jobs postings, job postings with IT skills, and job postings with AI skills



Source: Brookings analysis of Burning Glass Technologies data, available from Stanford HAI 2021 AI Index Report public data.

Figure 4. Production and adoption of AI remain low among US firms compared to other technology

Shares of firms engaged in AI production and adoption



Source: Brookings analysis of U.S. Census Bureau Annual Business Survey data.

Indeed, firm-level surveys, including by the U.S. Census Bureau, further illustrate the relatively small scale of AI activity. Compared to other advanced technologies such as cloud-based services and specialized equipment or software, the adoption of AI technology among U.S. firms remains far from pervasive. Only 3% of all U.S. firms had adopted AI applications as of 2018, and an even smaller percentage is engaging in AI solution production (Chart 4).

The upshot for all this data is that the excitement abound AI is justified, but its adoption is still in its nascent stages.

FINDING 2. AI ACTIVITY IN THE U.S. IS HIGHLY CONCENTRATED IN A SHORT LIST OF 'SUPERSTAR' AGGREGATIONS AND EARLY ADOPTER HUBS.

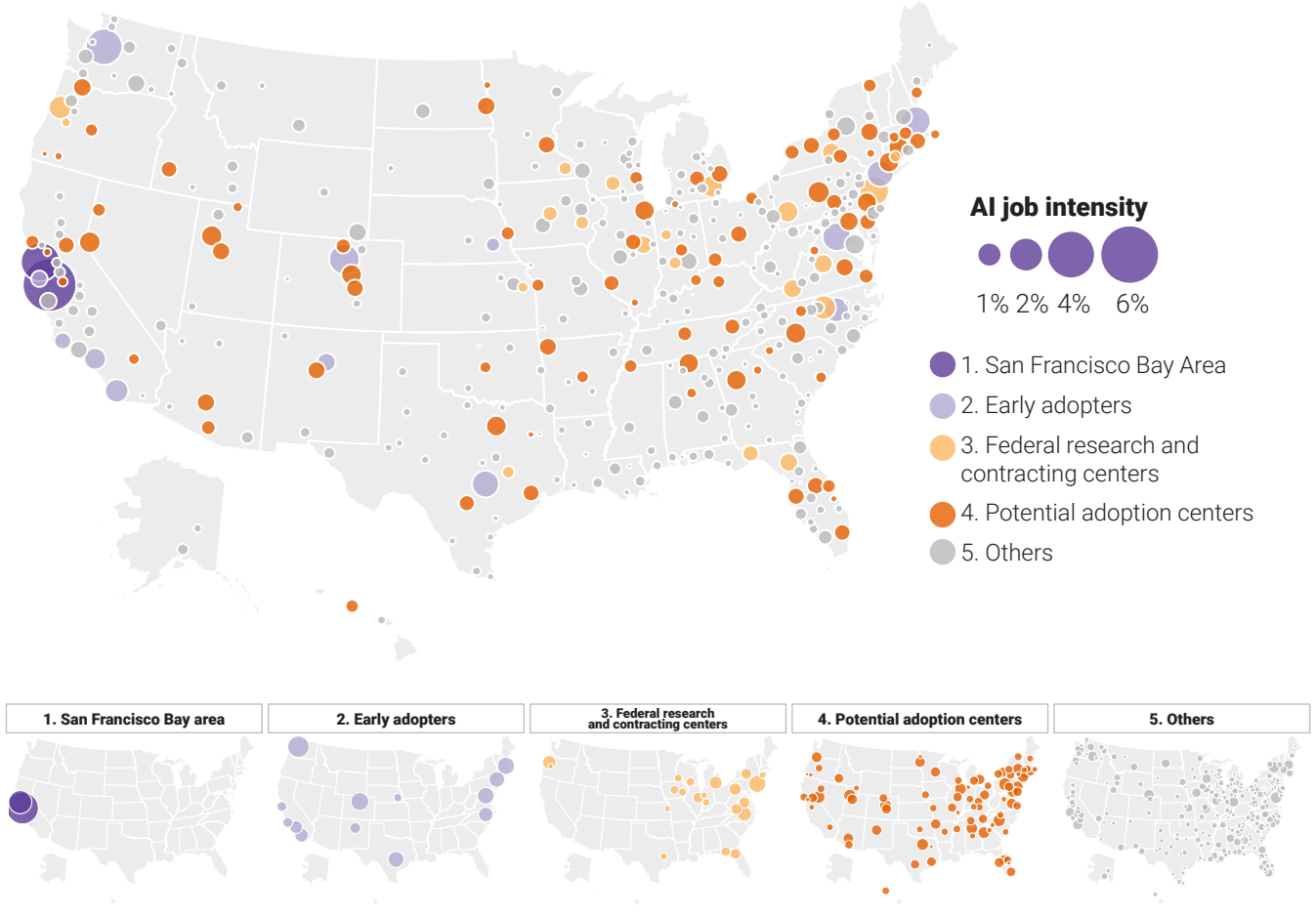
Despite the buzz, a very small number of metro areas dominate AI activity in the U.S. (Map 1).

In fact, only 36 U.S. metropolitan areas have developed truly substantial AI presences of any sort, according to our cluster analysis. What's more, the nation's emerging AI geography is even more concentrated into just 15 key metro areas.

California's **Bay Area**, with its two metro areas of San Francisco and San Jose, alone accounts for about one-quarter of AI conference papers, patents, and companies. Add in the 13 "early adopter" metro areas, and these 15 metro areas encompass about two-thirds of the nation's AI assets and capabilities. The next tier of AI activity consists of 21 metro areas that have achieved success in winning federal research and development grants and contracts. Beyond that, another 87 metro areas exhibit moderate AI activities, while no significant AI activities were detected in the rest of the nation's 261 metro areas.

While the last year has seen a modest pandemic-era decentralization of AI-related job postings, the strong concentration of the sector almost certainly persists, though equally recent data are not yet available for all measures.

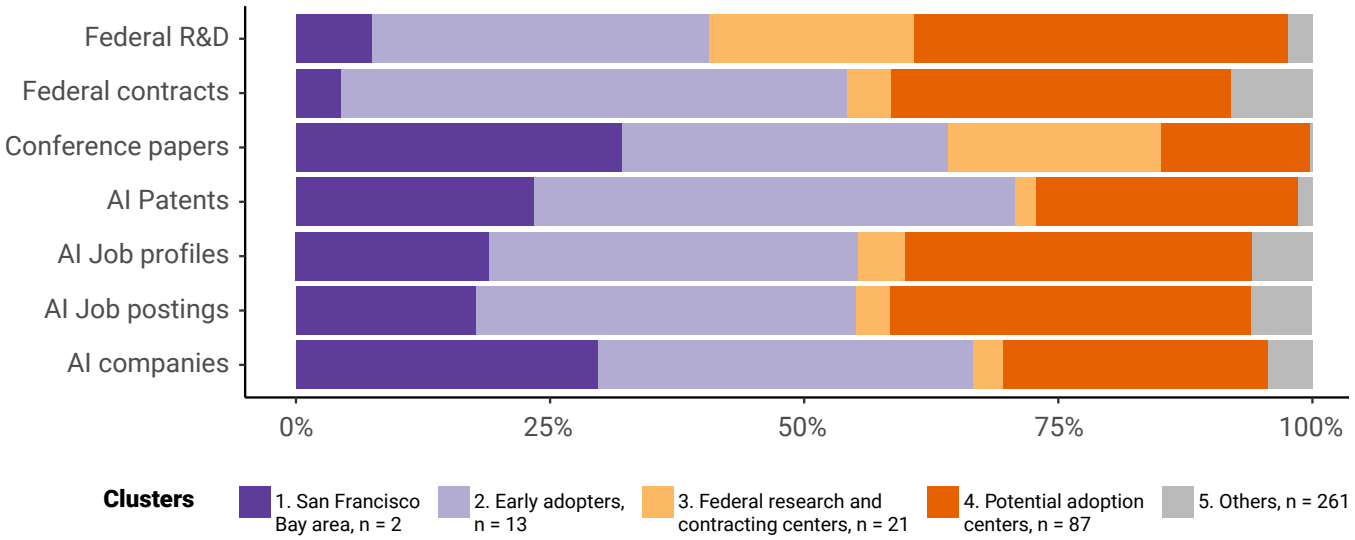
Map 1. AI employment concentration by U.S. metropolitan area
Share of job postings with AI skills by five types of AI metro clusters



Source: Brookings analysis of Stanford HAI, Crunchbase, STAR METRICS, USPTO, and Emsi data.

Figure 5. AI activity is highly concentrated

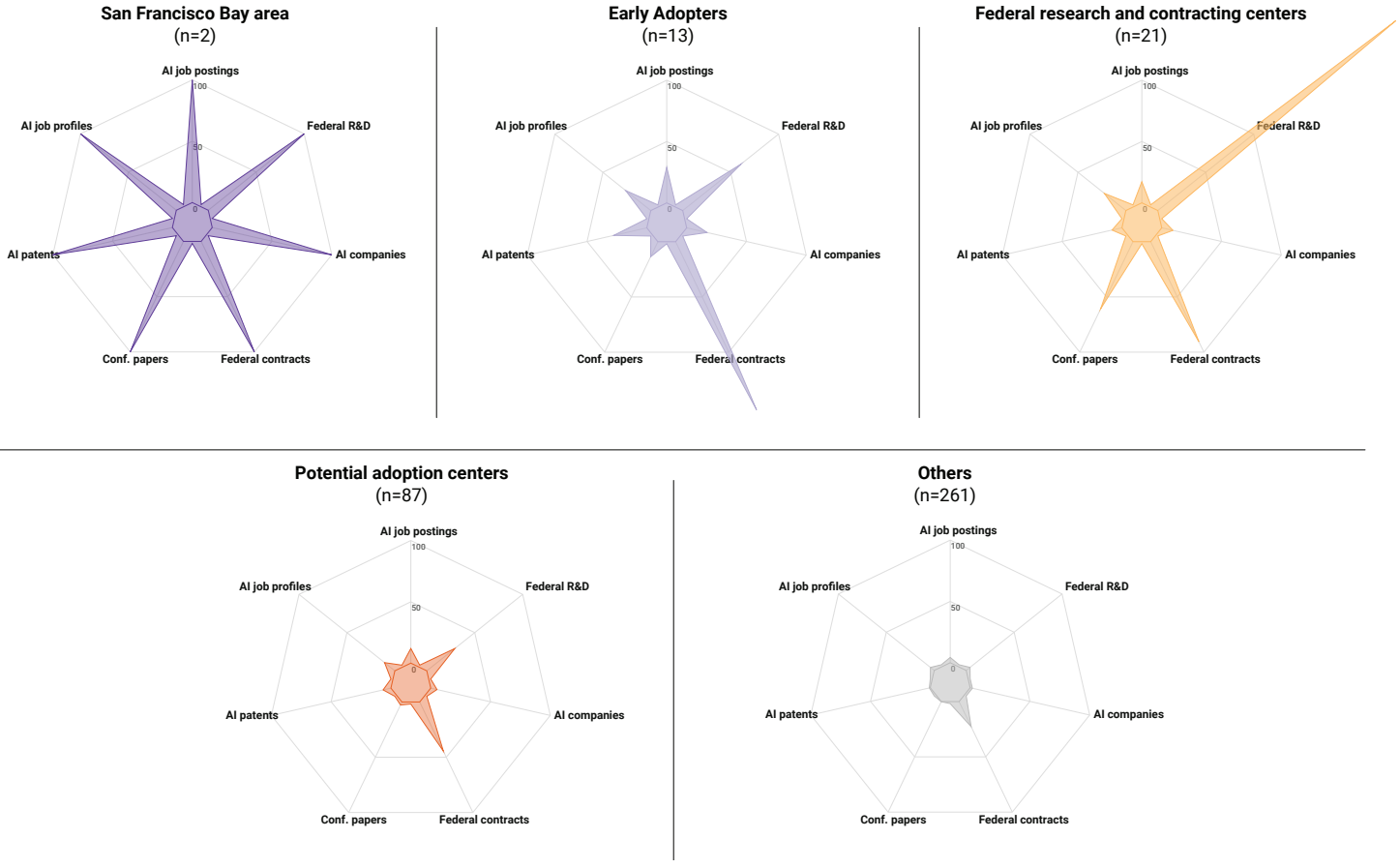
Share of total AI activities by five types of AI metro clusters



Source: Brookings analysis of Stanford HAI, Crunchbase, STAR METRICS, USPTO, Emsi data.

Figure 6. Five configurations of metro-area AI activity can be discerned

Indexed per capita AI capacity levels for five types of AI metro cluster (San Francisco Bay Area = 100)



Source: Brookings analysis of Stanford HAI, Crunchbase, STAR METRICS, USPTO, Emsi data.

By all measures, the Bay Area—including both the San Francisco and San Jose metropolitan areas—now reigns as the nation's dominant center for both AI research and commercialization activities. The Bay Area agglomeration is the nation's "superstar" hub. In per capita terms, the combined Bay Area metros together boast about four times as many AI companies, jobs postings, and job profiles than the average values for the next tier of "early adopter" metro areas. While the Bay area's dominance is relatively weaker in federal research and development funding and contracts, it's still significant. In fact, the two metro areas still receive significantly higher public AI investment compared to all clusters except for the "federal research and contracting centers" group (Chart 5).

The AI research strengths of the Bay Area rely on investment from both public and private efforts. The region is home to the world's top universities in AI research (Stanford and the University of California, Berkeley) as well as leading companies that invest heavily in AI research and development, including NVIDIA, Alphabet (Google), Salesforce, Facebook, and others. On top of its research capacities, the region's strong innovation ecosystem is very successful in translating research into applications, characterized by its high patenting and startup rates.

Beyond that, 13 "early adopter" metro areas have shown above-average involvement in AI activities. These include eight large tech hubs—**New York**; **Boston**; **Seattle**; **Los Angeles**; **Washington, D.C.**; **San Diego**; **Austin, Texas**; and **Raleigh, N.C.**—and five smaller metro areas that have substantial AI activities relative to their size: **Boulder, Colo.**; **Lincoln, Neb.**; **Santa Cruz, Calif.**; **Santa Maria-Santa Barbara, Calif.**; and **Santa Fe, N.M.**

These regions possess strong research institutions and have been successful in developing and deploying commercial applications from research and translating them into high-value growth companies. Many of these early adopters benefit from hosting national AI leaders such as Oracle, IBM, Amazon, and CrowdStrike, a cybersecurity firm. A majority of AI job postings in early adopter metro areas come from the regional hubs of these tech giants (Table 2).

Nor are the regional lists dominated exclusively by "big tech" or tech firms in general. Instead, some of the largest regional employers of AI talent are large corporations outside the tech industry, exemplified by the financial giants in New York. Those industry leaders have pioneered AI adoptions in their sectors, successfully incorporated AI application into their core business functions, and are now hiring steadily.

With that said, just two "superstar" metro areas and 13 "early adopters" anchor the entire nation's emerging AI map by bringing substantial research activities and major commercial activity into close proximity.

Table 2. Top AI employers in 'early adopter' metro areas

Metro area	Top AI employers
Austin, Texas	Dell, IBM, CrowdStrike, Oracle, Amazon, AMD
Boston	Oracle, Amazon, Capital One, IBM, Hired, Wayfair
Los Angeles	CrowdStrike, Oracle, Deloitte, IBM, Anthem, Disney
New York	Oracle, IBM, Amazon, Capital One, JPMorgan Chase, Deloitte
Raleigh-Cary, N.C.	IBM, Oracle, Deloitte, Lenovo, Applied Research Associates
San Diego	Qualcomm, Oracle, CrowdStrike, Intuit
Seattle	Amazon, Microsoft, Facebook, Oracle, Apple
Washington, D.C.	Capital One, Booz Allen Hamilton, Leidos, IBM
Boulder, Colo.	Oracle, Amazon, Soundhound, Apple
Lincoln, Neb.	American Express, University of Nebraska
Santa Cruz-Watsonville, Calif.	CrowdStrike, University of California, Hired, Joby Aviation, Amazon
Santa Maria-Santa Barbara, Calif.	CrowdStrike, University of California, Toyon Research Corporation, AppFolio
Santa Fe, N.M.	American Express, Descartes Labs

Source: Brookings analysis of Emsi data.

FINDING 3: NUMEROUS RESEARCH AND CONTRACTING CENTERS OWE THEIR STANDING TO FEDERAL RESEARCH AND DEVELOPMENT

Benefiting from federal research and contracting activities, 21 additional metropolitan areas have built up sizable AI capacities by capturing significant federal spending on AI-related projects.

Federal investment, in this regard, has always been crucial in the earliest stages of industrial development, and AI is no exception. Given its nascent stage of development, the field of AI science is being substantially propelled by significant research investment to solve key problems, venture into new territories, and develop meaningful applications and commercial promises. In keeping with that, federal research and contracting has materially shaped the nation's emergent AI geography by investing in AI work in the nation's research and contracting centers.

These federal centers include large metro areas that are anchored by a major research university or institution. With the exception of **Pittsburgh**, **Durham, N.C.**, **Madison, Wis.**, and **New Haven, Conn.**, many metro areas in this group are small in size, with fewer than 200,000 residents, and may be deemed "university towns." Notably, AI activities within these regions are almost always highly concentrated in just a few sizable institutions, highlighting the unique role of public investment into public universities in advancing cutting-edge technologies in small geographies (Table 3).

This group of metro areas is particularly successful in securing research and development funding through local research universities and private institutions, winning federal contracts, and publishing at leading AI academic conferences. However, these metro areas exhibit below-average commercialization activities in terms of per capita AI companies, job postings, and job profiles. As such, these centers represent an important but secondary tier of the nation's AI economy.

Table 3. Federal research and contracting centers

Metro area	Key institutions with AI research activities
Ames, Iowa	Iowa State University
Ann Arbor, Mich.	University of Michigan
Blacksburg-Christiansburg, Va.	Virginia Tech
Bloomington, Ind.	Indiana University
Champaign-Urbana, Ill.	University of Illinois
Charlottesville, Va.	University of Virginia
College Station-Bryan, Texas	Texas A&M University
Corvallis, Ore.	Oregon State University
Durham-Chapel Hill, N.C.	University of North Carolina
Eugene-Springfield, Ore.	University of Oregon
Gainesville, Fla.	University of Florida
Iowa City, Iowa	University of Iowa
Ithaca, N.Y.	Cornell University
Lafayette-West Lafayette, Ind.	Purdue University
Lawrence, Kan.	University of Kansas
Madison, Wis.	University of Wisconsin
New Haven-Milford, Conn.	Yale University, Haskins Laboratories
Pittsburgh	University of Pittsburgh, Carnegie Mellon University
Rochester, Minn.	Mayo Clinic
Tallahassee, Fla.	Florida State University
Trenton-Princeton, N.J.	Princeton University

Source: Brookings analysis of STAR METRICS data.

FINDING 4: NEARLY 90 ADDITIONAL COMMUNITIES ARE POTENTIAL AI ADOPTION CENTERS.

Eighty-seven additional metro areas have developed some AI research and commercialization capacities, but at levels well below the average of the 36 more established metro areas. This group includes some of the nation's largest commercial hubs, such as **Atlanta**, **Chicago**, **Houston**, **Dallas**, and **Detroit**, as well as small college towns such as **Athens, Ga**. (University of Georgia), **State College, Pa**. (Pennsylvania State University), and **Bloomington, Ill.** (Illinois State University). Several up-and-coming tech hubs—including **Fort Collins, Colo**.; **Provo, Utah;** and **Nashville, Tenn.**—are also on the list.

On a per capita basis, the AI capacities and resources in these 87 metro areas are less than half of those in the "early adopter" group across all indicators. In particular, even though these potential adoption centers received relatively generous federal research and development funding—about half the average level of "early adopters"—they failed to generate a similar level of research outputs, including federal research contracts, publications at leading AI conferences, and AI patents.

Still, these are potentially notable AI centers, and their AI activities are not insignificant. Collectively, they produce about one-quarter of all U.S. AI patents and companies and account for more than 30% of AI jobs and workers (Table 4).

Many of the nation's best artificial intelligence startups were founded in one of these potential adoption centers, such as **Salt Lake City's** Recursion, a biotech firms using AI for drug discovery; **Columbus, Ohio's** Olive, a $1.5 billion health care startup that uses AI to improve operation efficiency; and **St. Louis'** Benson Hill, a company that combines AI with genome editing and plant biology.[18]

Beyond that, numerous larger metro areas in the "potential adoption centers" group are home to major clusters of Fortune 500 companies that, together with smaller firms, could become centers for the adoption of AI by major industry players. These clusters are frequently anchored by industry leaders that are often the most likely to invest in developing AI applications in both product development and internal operations.[19] Pharmaceutical companies such as AbbVie (based in **Chicago**) and Eli Lilly (**Indianapolis**) are at the forefront of AI adoption in drug development, for example. Health care firms such as HCA Healthcare (**Nashville, Tenn.**), DaVita (**Denver**), and Tenet Healthcare (**Dallas**) are leveraging AI in diagnostics, precision medicine, and patient adherence. Manufacturing firms such as Cummins (**Indianapolis**), Honeywell (**Charlotte, N.C.**), and General Motors (**Detroit**) are leaders in the application and adoption of AI technology. And big retailers such as Walmart (**Fayetteville-Springdale-Rogers, Ark.**) and Target (**Minneapolis**) have been experimenting with AI technology in everything from product inventory predictions to virtual try-on with augmented reality technology.

Many smaller metro areas on the list are also gaining traction as national tech giants add "satellite tech hubs" to expand their talent pools. **San Luis Obispo, Calif.**, for example, has successfully attracted tech-

Table 4. AI activity profile: Potential adoption centers

Indicators	AI total	% of US AI Total
Federal R&D grants, 2010 - 2019	8,507	37%
Federal contracts, 2010 - 2019	664	33%
Conference papers, 2019, 2020	408	15%
AI Patents, 2010 - 2019	1,733	26%
AI Job profiles, 2019	172,820	34%
AI Job postings, 2019	154,054	36%
AI companies, 2019	2,342	26%

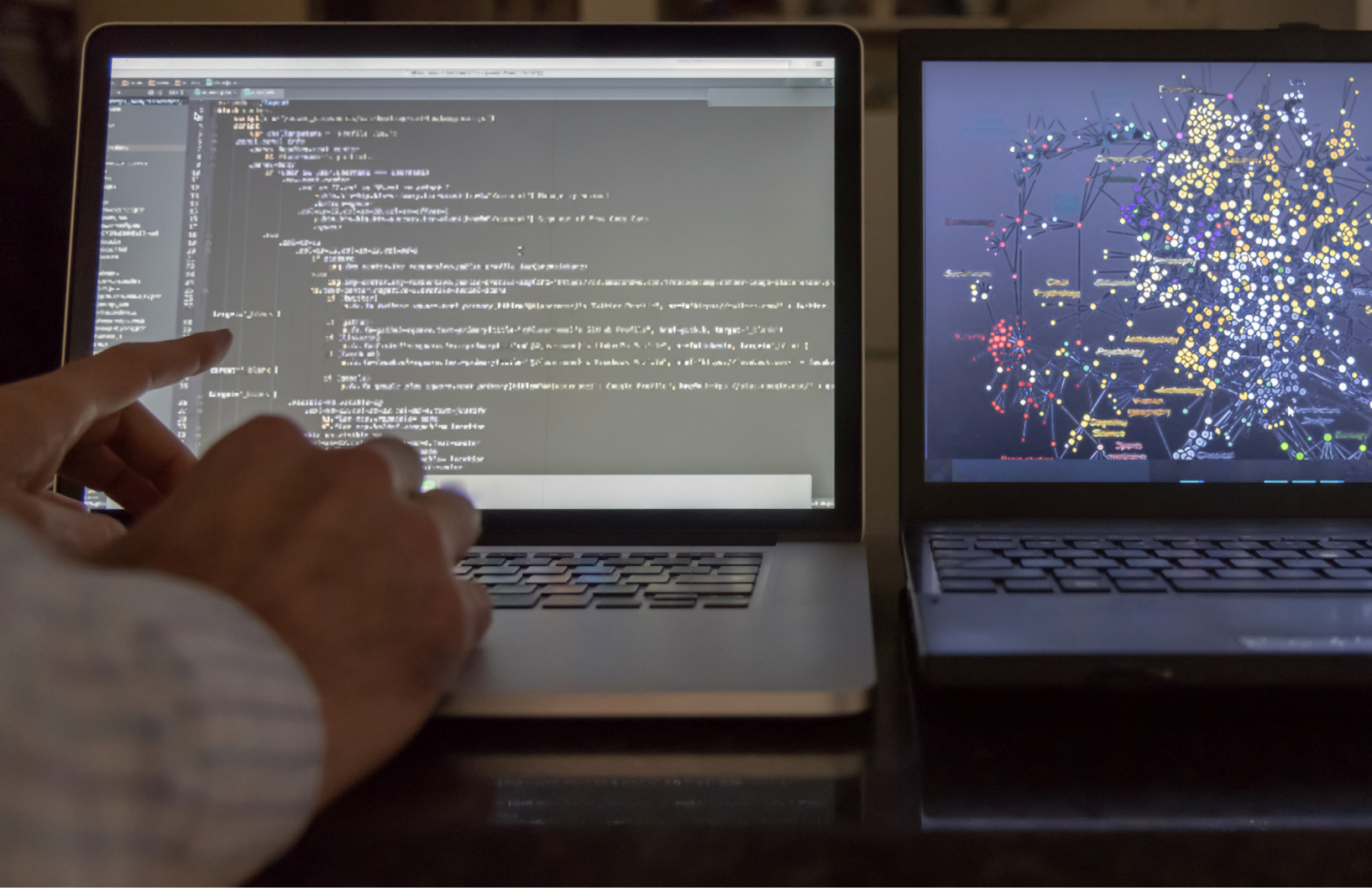
Source: Brookings analysis of Stanford HAI, Crunchbase, STAR METRICS, USPTO, and Emsi data.

based expansions from companies such as Amazon Web Services and GE Digital by offering a strong entrepreneurial ecosystem for tech startups and a steady pipeline of computer science graduates from California Polytechnic State University.[20]

Growing federal support will likely also begin to flow to places beyond the superstar and early adopter group orbit in the next few years. In July, for instance, the National Science Foundation (NSF)established 11 new AI research institutes with ties to 40 states with an investment of over $220 million, building on an earlier first round of institutes funded in 2020.[21] **Oklahoma City, Okla**.; **Rochester, N.Y.;** and **Atlanta** are among the potential adoption centers that will receive these sizable investments in the next five years. And more communities will likely see such inflows given the sizable federal research and technology investments being prioritized in the U.S. Innovation and Competition Act.[22] These plans explicitly prioritize significant investment in artificial intelligence, machine learning, high-performance computing, and quantum computing as a matter of national urgency.

In sum, these nearly 90 additional communities stand out as an important set of potential growth centers as AI technology diffuses in the coming years. AI adoption in some of the regions may be a significant dimension of their development in the next decade.

These 90 hubs' assets and capacities also set them apart from the remaining 261 metro areas that do not exhibit meaningful AI activities. That this sizable remainder of metro areas accounts for just 5% of the nation's AI activities across all indicators is a sign that this cutting-edge technology is far from a ubiquitous feature of local economies.



Discussion

The statistics, analysis, and mapping presented here suggest both the relevance of AI for regional economic development discussions and its challenges.

On the upside, AI is a powerful general purpose technology that is growing rapidly and could increase the productivity of virtually all regional economies. No wonder numerous regional development leaders are assessing the AI opportunity. AI can and should be part of the discussion as leaders seek to position their locales to create or adopt the emerging technologies that may inflect the pace of economic growth in the next decade following the pandemic.

Accordingly, some metropolitan areas (depending on their size and starting point) may decide to pursue robust investments in research and commercialization capacities, smart adoption strategies, or smaller interventions to generate a local entrepreneurial "flywheel" in an area of clear advantage.

At the same time, the information in this report suggests that the task of developing a significant AI cluster could be challenging in many regions.

Though it is growing, the industry remains small, with its firm distribution skewed to Big Tech giants, large IT-enabled firms, and local startups. However, not all places are seeing such activity, or host large AI adopters. What's more, substantial research activities and specialized workforce talent are prerequisites for high-level success—yet are hard to amass. And as the current preeminence of a few AI "superstars" and early adopter metro areas suggests, the intense clustering and "platform" aspects of the AI economy mean that "relatively few places will drive the bulk of early-stage AI-related development," as Alan Berube and Max Bouchet have written of Louisville, Ky.'s situation.[23] That means that the AI prospects of many potential AI adoption centers could be circumscribed as the AI "rich" get richer by dominating the creation of AI technologies and their highest value applications.

And so, the present is a critical moment for national and regional assessment of how to enhance the local and national AI economy.

For its part, the federal government is in the midst of a new realization that national action will be necessary to both expand new investments in AI research and development and distribute them more widely to counter their current concentration in just a few geographic regions.[24] Hopefully, the passage and implementation of the U.S. Innovation and Competition Act this year—with its sizable AI research and development allocations and regional technology hubs—will address both these objectives. Such legislation and new federal support for STEM education should allow more regions to pursue more varied and promising AI technology pathways.

For their part, cities and regions—cognizant of the "digitalization of everything" in the wake of the COVID-19 pandemic—remain alert to AI's potential, and in many instances want to explore it as an economic development opportunity. Leaders are right to do that, but as this report suggests, the varied character of AI cities requires that regions assess their positioning and capabilities clearly and develop differentiated strategies for AI development. What follows are initial strategy considerations keyed to each of the AI city types identified in the present report.

THE BAY AREA 'SUPERSTAR' REGION

As the nation's preeminent AI "superstar," the Bay Area will likely see its leadership status reinforced given the inherent "winner-take-most" dynamics of digital industries. Given that, the region's AI development priorities in the coming years should be ethical and progressive as much as they are competitive.

Along these lines, Bay Area leaders should consider two sorts of opportunities for the region's further development. First, the Bay Area AI ecosystem should move now to distinguish itself as the world leader in building ethical AI. Bay Area companies are already highly influential in shaping the future of AI; local innovations, regulations, and industry practices could set forth examples for national or international standards on ethical design, use, and explainability. San Francisco, for example, early on made itself the first city in the nation to ban the use of facial recognition by city agencies and law enforcement.[25] Likewise, San Francisco State University launched the nation's first graduate certificate in ethical AI.[26] Such creativity and humane development are compelling both as a way for the region to differentiate itself and to influence the rest of the world.

At the same time, the Bay Area's dominance underscores its responsibility to benignly shape the future of the U.S. AI economy. Much has been written about the frequent racial biases of algorithms trained by unrepresentative data. But the problem extends beyond the technology itself, to the homogeneity of the broader industry, particularly in the Bay Area.[27] Accordingly, the Bay Area—as the national and world leader on AI standard-setting—needs to lead on fixing the industry's diversity problem with new approaches and effective solutions. Also important will be making sure the region is a safe and welcoming place for minorities—especially Asian Americans, who account for more than two-thirds of the region's new tech workers.[28]

With its powerful actors in AI, the Bay Area should also assume a leadership role in bringing about a more geographically distributed AI economy. Already, the nascent U.S. AI economy appears headed for heavy concentration in the Bay Area and a few other places. Therefore, it is not too soon for big and small firms to consider distributing business units, investments, and talent into promising, farther-flung locales in order to build a more decentralized, diverse, and inclusive AI industry. Deconcentrating themselves to reduce groupthink, tap diverse talent, and disrupt accumulating biases looms as a critical next phase for the Bay Area's AI superstars.

EARLY ADOPTERS

The "early adopter" metro areas have emerged as significant AI centers outside the Bay Area. These regions have developed solid regional advantages because of their strong research capacity and commercialization ability compared to other regions. But despite their strengths, the gap between early adopters and the Bay Area remains wide, and their overall AI activity is still a very small portion of their economies.

Overall, leaders of these early adopters—including **Austin, Texas**; **Boston**; **New York**; **Seattle**; and **Boulder, Colo.**—should continue doing what they are doing, with a focus on building strong overall ecosystems oriented to top-quality research, application, acceleration, and commercialization to systematically foster both AI tech creation and adoption.

BUILDING AN AI 'SUPERCLUSTER' IN TORONTO

Though outside of the U.S., Toronto's Vector Institute represents the boldest sort of ecosystem-building by an early adopter metro area making a sustained bid for leadership.

The Vector Institute was created amid a sense of urgency prompted in the last decade by the frequent poaching of Canada's world-leading AI talent by top universities and tech companies in the U.S. and elsewhere. With the goal of retaining and attracting top AI talents and developing industry-transforming business applications, the Canadian national government, the government of Ontario, and industry leaders committed $100 million in funding in 2017 to build a sustainable AI "supercluster" in Canada, with the Vector Institute at its center.

To that end, the institute centers its initiatives around world-class AI research, AI adoption across various industries, and development of a robust AI workforce pipeline.

To foster dynamic research exchanges, the institute maintains access to top talent in the field through its partnership with the University of Toronto, and provides faculty and students there the opportunity to develop and commercialize their research. Overall, the Vector Institute encompasses more than 500 faculty members and graduate researchers working across different fields of AI. Vector faculty members host regular seminars and talks to create a platform for idea sharing and collaboration. A versatile range of hardware and related technology infrastructure are available to Vector members for research. During the COVID-19 pandemic, the infrastructure enabled data-intensive analysis that informed public health decisionmaking.

To catalyze near-term AI adoption, one key Vector program facilitates face-to-face meetings for corporate sponsors to meet with the institute's researchers for advice on highly specific AI challenges. The health care sector, in particular, has been identified as a key area of industry-university collaboration. Initiatives around health data access, cross-disciplinary health data research, and clinical AI development are underway with universities, hospitals, and health care providers.

Finally, to prepare Ontario for an AI-intensive future, the Vector Institute is also working with postsecondary institutions in the region to develop AI programs that respond directly to employers' needs. In its first three years of operation, Vector helped develop four new degree programs and 12 new AI concentrations, with more than 800 AI master's students enrolled. In addition, the Vector Scholarship in AI has attracted more than 250 students from around the world to study AI in Ontario's universities.

Overall, the Vector Institute represents one of the most ambitious efforts in North America to upgrade a strong ecosystem into a world-class position.

Source: https://vectorinstitute.ai

For these regions, large-scale and sustained initiatives to "go big" on efforts to build consequential AI clusters based on both research and commercialization could make sense. Building major AI research hubs including by securing federal research awards and engaging Big Tech firms would advance local progress. Early adopter metro areas should also strive to gain a first-mover advantage in new AI application territories, including ethical AI, which may emerge as a point of comparative advantage.

One other possible strategy relates to the fact that AI penetration remains low among early adopters in sectors outside of their core tech industries. Given that, early adopter metro areas may want to carve out new competitive niches that combine their strengths in AI research and commercialization with existing industry specializations, thus developing breakthrough AI solutions for larger regional industry clusters.

In that sense, a crucial pathway forward for early adopters is to pioneer new technology for new use cases in the larger economy. For an example of such development, early adopter metro areas should look at the RLab, a $5.6 million partnership to develop augmented and virtual reality technologies in New York City.[29] Funded by the New York City Economic Development Corporation and the mayor's office, RLab was created in partnership with NYC Media Lab, a consortium of academic institutions, to accelerate the convergence of AI and augmented reality/virtual reality (AR/VR) technologies with the city's strong health care, real estate, entertainment, gaming, and design industries. To that end, RLab works to expand the New York talent pipeline with AR/VR education programs; support early-stage AR/VR startups with workspace and capital; and support corporate innovation projects. In that way, the lab suggests how early adopter metro areas can build on their strengths to develop new sources of commercial advantage.

RESEARCH AND CONTRACTING CENTERS

AI research and contracting centers—whether in **Ann Arbor, Mich.**; **Durham-Chapel Hill, N.C.**; **Madison, Wis.**; or **Pittsburgh**—depend on federal research and development funding for their status in the AI economy. For them, maintaining the current momentum of AI science both within their research universities and across the federal innovation budget is key to preserving or growing their presence. For that reason, research and contracting centers should become fierce advocates for their university AI concentrations and for federal investment in key research areas such as AI, machine learning, high performance computing, semiconductors, and advanced computer hardware.

But that won't be sufficient. If these places want to reap broader economic benefits from AI, they need to drive a surge of local commercial activity in order to broaden their AI presence. At present, too few of these centers see meaningful levels of AI-related business activity; as a result, AI adoption in these regions will likely turn out generic and commodified, rather than differentiated.

To begin to bolster their commercial presence, research and contracting centers should forge more corporate research partnerships with their universities to forge technology for use, promote entrepreneurship, and work on AI talent retention and attraction.

On pursuing corporate research, most of the research and contracting centers lack a leading technology firm. Nevertheless, these regions could strive to establish strong partnerships between their research universities and top technology consuming firms, which are spread across virtually all of America's advanced industries. In fact, many tech companies are seeking to build partnership with universities with strong research capacities and talent pipelines. For example, the University of Florida was able to secure a $50 million gift from NVIDIA, the Silicon Valley AI computing company, to host an AI supercomputer on campus, develop an AI-centered curriculum for students (including those from underrepresented groups), and hire more faculty members focused on AI.[30] Meanwhile, a Catalyst Fund at the school has awarded grants to 20 faculty teams to pursue often applied AI research solutions. The NVIDIA partnership is an important step beyond pure research, potentially on the path toward other research contracts and alliances, including for critical new product development.

For other research and contracting centers, broader ecosystem-building—with a focus on tech transfer, entrepreneurship, finance, partnerships, and talent—will be key. Most importantly, talent retention and attraction need to become top priorities of all 21 research and contracting centers. These metro areas' thin flow of AI job postings raises the threat of a "brain drain" among both faculty and graduates at local universities,

with dangerous consequences. A brain drain has the power to hollow out not just these cities' scientific strengths but also what commercial activity they do have. Without commercial opportunities, both AI professors and students may head elsewhere, with research showing that AI professors' departures reduce the creation and early-stage funding of startups by students who graduate from these universities.[31] Given that, research and contracting centers should redouble their efforts to recruit and retain AI faculty and steadily build the AI talent pipeline to support commercial growth as it occurs. In addition, with the tech industry embracing remote work, cities may want to bring home those who have worked at or built successful AI startups elsewhere, but are seeking to move back to where they grew up or went to school.

POTENTIAL ADOPTION CENTERS

For the 87 potential AI adoption centers—which currently lack both significant research and commercial activity—any AI development strategy must be highly realistic. The difficulty of building up AI innovation capacities is daunting, given the expense of expanding university research programs. And given these metro areas' minimal levels of AI business activity (paired with the "winner-take-most" nature of high-tech economies) caution about the way forward is essential.

But given the genuine strengths some of them possess, the nation's potential adoption centers should not write themselves off. Instead, these metro areas must bring special care to shaping any local development strategy. Should they proceed, they will likely find their best advantage lies in supporting the exploration of use cases for AI adoption in key local industries, actively facilitating such adoption, and eventually seeking opportunities to move to AI production and AI creation by leveraging insights from AI adoption practices.

The first step is likely to conduct a thorough assessment of the metro area's current AI positioning, as Louisville, Ky. did earlier this year.[32] By tying strategy development to a data-intensive benchmarking exercise, Louisville clarified both its weakness on AI innovation metrics as well as its potential to build on its sizable "data economy" as an arena for AI adoption. Now that region has a realistic sense of itself amid the national buzz on AI—and a strategy.

STRATEGIZING FOR TALENT, ADOPTION, AND COLLABORATION IN LOUISVILLE

Louisville, Ky., like many other AI potential adoption centers, faces a series of stark economic and social challenges. It is at once attempting to maintain (if not expand) its historical competitive advantages in industries such as health care and advanced manufacturing, while also striving to close long-standing gaps by race and place foregrounded in the wake of Breonna Taylor's tragic death in 2020.

Recognizing these imperatives, Louisville Metro (the consolidated city-county government) partnered with Microsoft in 2019 to create the Louisville Future of Work initiative. The initiative aims to position the city and region as a stronger midsized hub for AI, data science, and the Internet of Things; to support industry development by helping local businesses adopt new technologies; and to transform the local workforce into the most data-credentialed per capita in the nation.

As part of this effort, Brookings Metro partnered with the Future of Work initiative to produce a precursor to this report: a first-of-its-kind metropolitan benchmarking of AI positioning and preparedness that compares Louisville to 16 of its peer regions in the greater Midwest and Southeast.[33] The report shed light on not only AI-specific activities and competencies involved in the production of AI technologies, but also a wider range of adjacent data economy attributes that may indicate Louisville's readiness to adopt AI technologies at greater scale.

Overall, the report found that Louisville ranks lower than most of its peer cities on AI-specific measures of innovation, talent, and startup ecosystem. Yet the report also concluded that Louisville has a considerable base of talent and companies specialized in the

wider data economy—most notably in key clusters such as health care and business services. The report urged Louisville to marshal its AI-relevant assets and institutions toward a more specific, shared vision for competitive and inclusive growth, highlighting three areas for deepened focus and investment:

- **Broadening and diversifying the AI talent pipeline.** Regional leaders, suggested the report, should sustain and scale emerging talent development efforts at all levels, including secondary, postsecondary, retraining, and continuing education. These efforts must involve strong connections to local employers and deeper reach into communities of color, while emphasizing the cultivation of specific AI-related skills (e.g., in data management and algorithm development).

- **Supporting AI adoption and adaptation.** Next, the report urged Louisville leaders to build a stronger local ecosystem—particularly in areas of existing sectoral and data economy strength, such as lifelong wellness and aging—involving startups, middle-market companies, large corporations, and civic institutions. The report also suggested that the needs and involvement of women- and minority-owned businesses be centered.

- **Developing and marketing the metro area's AI niche in the broader region.** Finally, the report urged regional leaders join with larger Midwestern and Southeastern neighbors to explore the creation of a "super-regional" hub for AI- and data-economy-enabled health care solutions. In this respect, universities, chambers, and corporations across Indianapolis, Louisville, and Nashville, Tenn. could strategically share AI-enabled workforce, supply chain, and research assets in health care and life sciences that leverage their respective specializations, thus positioning themselves more prominently for businesses development and high-quality job growth.

These strategies are gaining additional momentum with Louisville recently joining Microsoft's Accelerate initiative, which aims to promote digital skilling for traditionally underrepresented and underserved communities, building on the Future of Work initiative's considerable success in that arena.

Louisville's strategy points in several directions relevant for other potential AI adoption centers. With leading-edge innovation less feasible, these places can begin with raising awareness and highlighting potentially significant AI adoption use cases. For example, educating the business community about the benefits of AI—such as through information and networking sessions—will be critical in the coming years, writes Daniel Castro.[34] As Castro notes: "Those that do not understand the potential value of AI are unlikely to use it, so local businesses need to learn about use cases for AI in their specific industries." Regional business networks and local economic development organizations exist to provide this kind of awareness-building to their business communities. At the same time, it is equally important that regional business networks help local firms assess their own business functions and reveal potential areas for AI transformation. AI tools are useless without a specific problem in need of solution.

Moving beyond raising awareness, regions can engage more directly in spurring AI adoption. The creation of new AI technology is difficult without deep research capabilities and major capital investment. But it's very much possible for potential AI adoption centers to reap significant benefits from AI by facilitating the exploration of new use cases by local firms or by promoting the adoption of off-the-shelf AI technology by local firms.

In the first instance, some potential adoption centers may benefit from their firms pioneering the development of compelling new uses for existing technology that are relevant to whole industries. In other cases, local governments can reduce the technical and capital barriers to more routine technology adoption by providing modest grants and tax incentives to local firms.

Alternatively, some local governments may decide to jump-start local AI adoption by modeling early adoption in their own activities. As Castro notes, "by proving the value of the technology and sharing best practices and lessons learned, the public sector can pave the way for adoption by small and medium-sized businesses." Alternatively, governments can use their own procurement to contract AI goods and services from local AI companies. This improves government services, and, at the same time, creates demand for young companies to supply.

And then, some regions may want to promote adoption by prioritizing support of the broader "data economy" as a less risky way to promote AI as a subset of the larger digital sector, given the interplay of data analytics and AI. This is the strategy Louisville worked out, and it has the benefit of meeting the tech and AI ecosystems where they are while providing a broadly supportive environment for AI adoption.

Finally, and most importantly, many potential AI adoption centers will likely realize the value of supporting the development of local training programs for AI skills. Louisville's strategy report, for example, prioritizes work to broaden the region's AI talent pipeline; other regions are focusing on scaling-up and diversifying local pathways to data economy skills and careers.

On this front, the fact is that success in seizing AI and data economy opportunities depends heavily on the skills and ingenuity of a region's residents, as Berube and Bouchet emphasize in the Louisville agenda. What's more, local talent development remains especially important, in part because not all cities will be able to recruit the top graduates of the best computer science programs in the country. Because of that, many potential AI adoption centers may choose to build up their local four-year computer science programs. But they may also want to develop a wider set of pathways than the usual college route. New pathways can include providing more advanced data science or AI training to high-potential workers who may already work in the broader data economy. Other pathways may entail providing more applied coursework in college, or more technical instruction in community colleges or high schools. Likewise, local governments and states may want to partner with local colleges and high schools to develop AI internship, apprenticeship, or certificate programs, with a special focus on underrepresented communities.

RESPONDING TO INDUSTRY NEEDS IN INDIANAPOLIS

Possessing major corporate headquarters in advanced manufacturing, the life sciences, and other tech-saturated industries, Indianapolis has embarked on an urgent campaign to retain those corporations by responding to their AI and data-science needs.

Motivating the region's push are worries that anchor firms such as Cummins and Eli Lilly and Company—which face disruptive technology needs associated with AI, data analytics, and the internet of things—have begun to look elsewhere for top-quality data science and AI talent, research, and applications development.

Given those concerns, a prominent CEO-based leadership group--the Central Indiana Corporate Partnership (CICP)--has embarked on a systematic effort to retain and grow the region's major advanced industries activity by creating a world-class data science research and development ecosystem intentionally designed to respond to specific industry needs.

To do that, CICP—with support from the Lilly Endowment Inc.—has moved to develop a broad-based but realistic strategy for creating a joint, place-focused investment platform and collaboration hub in Indianapolis. Pragmatic about the city's starting point, CICP has been deliberate in working out the specific value proposition of its initiative. This work has entailed several major analytic initiatives situating the state market, as well as exhaustive consultations with the state's major corporations and universities.

Building on those consultations, CICP and its partners have developed a multiyear strategy—called AnalytiX IN—to develop a broad platform of pertinent data science and strategy technology capabilities that can be readily translated into a variety of applications across the regional economy, starting with the life sciences and manufacturing. Powering that platform will be three activities:

- **Organizing around use cases and adoption.** Recognizing an urgent need for the demonstration and adoption of credible AI capabilities, Indianapolis planners believe a crucial advantage could be their ability to facilitate the identification of high-potential use cases, and organizing the needed problem-solving, investment, and acceleration to develop them. Rapid and strategic identification of industry-significant use cases—if decisively acted upon—could build both firm and regional competitiveness.

- **Activating and coordinating across three major universities.** With three major Indiana universities anchoring three research and contracting metro areas around the state, Indiana has significant academic resources in AI and data science—but little of it resides within 50 miles of Indianapolis. Given that, the AnalytiX IN will work directly with Indiana University, the University of Notre Dame, and Purdue University to draw their research and scholars into a strategic, intentional effort to build a hub of data science and AI applications work at the emerging 16 Tech Innovation District in Central Indiana. In that way, Central Indiana hopes to enlist the under-commercialized AI capabilities of three major universities in an urgent economic development partnership.

- **Prioritizing AI and data science education.** Finally, in addition to AnalytiX IN's focus on recruiting more industry-focused AI talent to the state's research universities, the initiative highlights the need for the state and its educational systems to prioritize the production of high-quality talent for AI and data science—beginning with K-12 education and extending into all communities, tiers of institution, and major universities.

In these ways, some potential AI adoption centers—while lacking major research and commercial capabilities now—can make realistic moves to ensure firms and workers in their regions participate in the growing AI economy.

OTHER METRO AREAS

As for the remaining 261 metropolitan areas—the majority of the nation's total—none of them have developed meaningful concentrations of AI activity. What's more, the AI fortunes of these communities could remain modest, especially since many of them lack a major research university, which limits their ability to gather talent around federal technology investment. As such, the nation's "other metro areas" face limited prospects as AI centers.

Leaders of these communities should be very cautious in assessing their prospects and attempting to boost them. With that said, promoting the adoption of off-the-shelf AI applications by local firms would likely be a prudent course, as it will be to a greater extent for the "potential adoption center" group.

Just as the earlier development stages of a disruptive technology frequently cluster development work in a few core hubs, the maturation of a technology—such as AI—usually brings a much wider diffusion of off-the-shelf applications. Ultimately, that diffusion should allow the broad adoption of AI even in the nation's least AI-oriented communities.

Should such diffusion transpire, even this group of communities may see the virtues of the kind of adoption strategies that some potential adoption centers are already exploring. For them, having a strong digital workforce will be critical when these new AI solutions arrive.

Conclusion

In short, AI could be poised to unleash the next wave of digital disruption later in this decade, and cities and metropolitan areas need to get ready for it.

AI matters because it appears to be a powerful, general purpose technology with great potential to promote firm and regional productivity as well as transform local labor markets. What's more, having an AI strategy matters because the technology's early adoption patterns already reflect wide gaps between the dominant Bay Area, a number of early adopter regions, and other tiers of city.

For this reason, the information and assessments in this report are meant more as a call to assessment rather than a call to immediate action. While not all—or even many—metro areas should try to be the next AI "superstar," many should assess their assets and capacities to ensure they are prepared for what will likely be a pivotal decade.

References

Agrawal, Ajay, Joshua Gans, and Avid Goldfarb. 2018. *Prediction machines: The simple economics of artificial intelligence."* Boston: Harvard Business Review Press.

Athey, Susan. 2020. "Written testimony: Hearing on machines, artificial intelligence, and the workforce: Recovering and readying our economy for the future." House Committee on the Budget.

Acemoglu, Daron, and Pascual Restrepo. 2020. "The wrong kind of AI? Artificial intelligence and the future of labour demand." Cambridge Journal of Regions, Economy and Society 13.1: 25-35.

Berube, Alan, and Max Bouchet. 2021. "How Louisville can become a stronger and more equitable hub for AI and data economy jobs." Washington. Brookings Institution.

Bloom, Nicholas; Tarek Alexander Hassan, Aakash Kalyani, Josh Lerner, Ahmed Tahoun. 2021. "The Diffusion of Disruptive Technologies." Working Paper 28999. National Bureau of Economic Research.

Bughin, Jacques, and others. 2017. "Artificial intelligence: The next digital frontier?" San Francisco. McKinsey Global Institute.

Brynjolfsson, Erik, and Georgios Petropoulos. 2021. "The Coming Productivity Boom." *Technology Review.* June 10.

Brynjolfsson, Erik, Daniel Rock, and Chad Syverson. 2017. "Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics." Working paper 24001. National Bureau of Economic Research.

Castro, Daniel. 2018. "How can smaller cities join the growing AI economy?" *Government Technology.* December.

Cortright, Joe, and Heike Meyer. 2001. "Signs of life: The growth of biotechnology centers in the U.S." Washington. Brookings Institution.

Furman, Jason, and Robert Seamans. 2018. "AI and the Economy." Working paper 24689. Cambridge. National Bureau of Economic Research.

Meserole, Chris. 2018. "What is machine learning?" Washington. Brookings Institution.

Muro, Mark, Jacob Whiton, and Robert Maxim. 2019. "What jobs are affected by AI?" Washington. Brookings Institution.

National Security Commission on Artificial Intelligence. 2021. "Final report: National Security Commission on Artificial Intelligence." Washington.

PricewaterhouseCoopers. 2017. "Sizing the Prize: What's the real value of AI for your business and how can you capitalize?" New York.

San Diego Regional EDC Research Bureau. 2020. "Measuring the future: AI and San Diego's economy." San Diego.

Szczepanski, Marcin. 2019. "Economic impacts of artificial intelligence." Brussels. European Parliament.

West, Darrell, and John Allen. 2018. "How artificial intelligence is transforming the world." Washington. Brookings Institution.

Zhang, Daniel, and others. 2021. "The AI Index 2021 Annual Report." Palo Alto. Human-Centered AI Institute.

Appendix: Technical background

Identifying AI projects using keywords

AI keywords for us in the analysis were obtained from the "WIPO Technology Trends 2019—Artificial Intelligence" report

	AI keywords used to identify AI profiles, jobs, patents, and federal R&D grants
Techniques	Deep learning
	Neural networks
	Reinforcement learning
	Rule learning
	Supervised learning
	Support vector machines
	Unsupervised learning
Applications	Augmented reality
	Computer vision
	Image and video segmentation
	Object tracking
	Scene understanding
	Information extraction
	Machine translation
	Natural language processing
	Sentiment analysis
	Speaker recognition
	Speech recognition
	Speech synthesis
	Speech-to-speech

Source: WIPO AI report.

DATA SOURCES

Federal R&D grants to universities on AI projects

Using the set of AI keywords, we searched for AI-related projects in the STAR METRICS system, the federal platform that tracks the impact of federally funded research.

Federal AI R&D contract spending to private firms

We aggregated project-level information from a database made public by Stanford HAI, built by Bloomberg Government, on federal AI-related contracts. The dataset contains government spending data from Federal Procurement Data System (FPDS) to both public and private institutions. To avoid redundancy, we only focused on contract spending on private firms for this analysis.

Academic papers at AI conferences

We compiled a list of authors and their affiliations using conference proceedings from International Conference on Machine Learning (ICML) and Conference on Neural Information Processing Systems (NeurIPS), two most selective AI research conferences. We chose to focus on the publications from top AI conferences as a proxy for research quality. We then assigned these publications to metropolitan areas based on university locations, or headquarter locations in the case of private companies.

AI-related patents

We use the same set of AI keywords to identify AI-related patents from patent descriptions, available from United States Patent and Trademark Office (USPTO). The location of patent assignees is used rather than the location of patent inventors, because we are mostly interested in where the patents are available for commercial use.

Companies providing AI solutions

We identify innovative AI companies from Crunchbase, a platform that tracks major investment deals. Companies on the Crunchbase platform are tagged with hundreds of categories, ranging from cutting-edge technologies such as autonomous vehicles, neuroscience, and 3D technology to niche markets including gamification, career planning, and content delivery networks. We reviewed all 700-plus categories, and manually selected the AI-related ones using our best judgement.

These category tags are: "artificial intelligence," "machine learning," "deep learning," "neural networks," "robotics," "face recognition," "image processing," "computer vision," "speech recognition," "natural language processing," "autonomous driving," "autonomous vehicle," "semantic web," and "image recognition."

Job postings require AI skills/Job profiles with AI skills

Job postings and job profiles data come from Emsi, a labor market intelligence firm. Emsi collects job postings data scraped from websites, and job profiles data from public, self-reported online resumes. Emsi uses a context-aware extraction tool to identify skills from these individual job postings and job profiles. We compiled a list of AI skills, and a job posting is considered to be an AI job if it contains at least one of the AI skills.

CLUSTER ANALYSIS

Cluster analysis is a statistical technique to identify observations that are similar to each other based on a set of predefined variables, but dissimilar from other groups of observations.

We performed k-means clustering on our dataset with 384 observations and seven variables, for different choices of k from 3 to 9. We treated the indicators for research activities and commercialization activities independently, and we review the results from both the research clusters and commercialization clusters to identify the grouping that reveals the most useful information.

Endnotes

1. See, for example, TEConomy Partners, LLC, "Artificial Intelligence and Advanced Analytics in Indiana: An Initial Discussion of Industry Needs and University Capabilities." (Columbus, 2020); San Diego Regional EDC Research Bureau, "Measuring the Future: AI and San Diego's Economy." (San Diego, 2020) and Alan Berube and Max Bouchet, "How Louisville can become a stonger and more equitable hub for AI and data economy jobs." (Washington: Brookings Institution, 2021).

2. See, for example, Oregon Workforce and Talent Development Board, Artificial Intelligence Task Force, "Talent Development and Artificial Intelligence." (Salem: 2020); Vermont Artificial Intelligence Task Force, "Artificial intelligence." (Burlington: 2020); TEConomy Partners, LLC, "Artificial intelligence and advanced analytics in Indiana: An initial discussion of industry needs and university capabilities." (Indianapolis: BioCrossroads, 2020); TEConomy Partners, LLC, "Ohio Bold: A blueprint for accelerating the innovation economy." (Columbus: Ohio Chamber of Commerce Research Foundation, 2018) and Blue Ribbon Commission with assistance from TEConomy Partners, LLC, "Recommendations on advancing the economic competitiveness of data analytics and computing in Arkansas." (Little Rock, 2017).

3. National Conference of State Legislatures, "Legislation Related to Artificial Intelligence," available at: https://www.ncsl.org/research/telecommunications-and-information-technology/2020-legislation-related-to-artificial-intelligence.aspx.

4. Shukla Shubhendu and Jaiswal Vijay. "Applicability of artificial intelligence in different fields of life." International Journal of Scientific Engineering and Research 1.1 (2013): 28-35.

5. Brad Smith and Harry Shum. "*The Future Computed*." Artificial Intelligence and its role in society (2018).

6. David Autor, Anna Salomons, and Bryan Seegmiller. "New Frontiers: The Origins and Content of New Work, 1940–2018." Forthcoming.

7. Fei-fei Li and John Etchemendy, "We Need a National Vision for AI", (Palo Alto: Human-Centered AI Institute, 2019).

8. Jacques Bughin and others. 2017. "Artificial intelligence: The next digital frontier?" San Francisco. McKinsey Global Institute.

9. PricewaterhouseCoopers. 2017. "Sizing the Prize: What's the real value of AI for your business and how can you capitalize?" New York; Nicholas Chen, et al. "Global economic impacts associated with artificial intelligence." Analysis Group (2016).

10. Erik Brynjolfsson and Andrew Mcafee. "The business of artificial intelligence." Harvard Business Review 7 (2017): 3-11.

11. Susan Athey. 2020. "Written testimony: Hearing on machines, artificial intelligence, and the workforce: Recovering and readying our economy for the future." House Committee on the Budget.

12. See, for example, Maryann Feldman, Frederick Guy, and Simona Iammarino, "Regional income disparities, monopoly, and finance." *Cambridge Journal of Regions, Economy, and Society* 14: 25-49; and Robert Atkinson and Mark Muro, "The case for growth centers: How to spread tech innovation across America." (Washington: Brookings Institution, 2019).

13. M. Storper and A. J. Venables (2004). Buzz: face-to-face contact and the urban economy. Journal of Economic Geography, 4(4):351{370.

14. Ibid, and also A. J. Scott (1983). Industrial organization and the logic of intra-metropolitan location: I. theoretical considerations. Economic Geography, 59(3):233-250.

15. Daniel Zhang and others, "The AI Index 2021 Annual Report." (Palo Alto: Human-Centered AI Institute, 2021).

16. Raymond Perrault and others, "The AI Index 2019 Annual Report." (Palo Alto: Human-Centered AI Institute, 2019).

17. Daniel Zhang and others, "The AI Index 2021 Annual Report." (Palo Alto: Human-Centered AI Institute, 2021).

18. "AI 100: The Artificial Intelligence Startups Redefining Industries - CB Insights Research". CB Insights Research, 2021, https://www.cbinsights.com/research/report/artificial-intelligence-top-startups/.

19. Michael Chui. "Artificial intelligence the next digital frontier." *McKinsey and Company Global Institute* 47 (2017): 3-6.

20. Kathy Chin Leong, "How Tech Expanded from Silicon Valley to Bubblegum Alley." December 19, 2017.

21. "NSF partnerships expand National AI Research Institutes to 40 states." News Release 21-012, July 29, 2021.

22. See "The United States Innovation and Competition Act of 2021: Section-by-section summary," available at USICA Section-by-Section 5.19.21.pdf (senate.gov). See also FACT SHEET: The American Jobs Plan | The White House

23. Alan Berube and Max Bouchet, "How Louisville can become a stronger and more equitable hub for AI and data economy jobs." (Washington: Brookings Institution, 2021).

24. See, especially, the National Security Commission on Artificial Intelligence, "Final report." (Washington: 2021).

25. Kate Conger, et al., "San Francisco Bans Facial Recognition Technology" New York Times, 14 May 2019, https://www.nytimes.com/2019/05/14/us/facial-recognition-ban-san-francisco.html.

26. Jared Council. "University Is Rolling Out Certificate Focused On AI Ethics". WSJ, 2019, https://www.wsj.com/articles/university-is-rolling-out-certificate-focused-on-ai-ethics-11558517400.

27. Tom Krazit and Joe Williams. "AI'S Diversity Problem". Protocol — The People, Power And Politics Of Tech, 2021, https://www.protocol.com/newsletters/protocol-enterprise/enterprise-ai-diversity-problem.

28. Sillicon Valley Indicators, Sillicon Valley Institute for Regional Studies. https://siliconvalleyindicators.org/data/people/talent-flows-diversity/tech-talent/new-tech-talent-in-the-core-working-age-group-25-44-table/. Accessed 23 August 2021.

29. https://www.rlab.nyc/. Accessed 2 May 2021.

30. Steve Orlando. "UF Announces $70 Million Artificial Intelligence Partnership With NVIDIA". News. Ufl.Edu, 2020, https://news.ufl.edu/2020/07/nvidia-partnership/.

31. M. Gofman, and Zhao Jin. "Artificial Intelligence, Human Capital, and Innovation." (2020).

32. Alan Berube and Max Bouchet, "How Louisville can become a stronger and more equitable hub for AI and data economy jobs." (Washington: Brookings Institution, 2021).

33. Alan Berube and Max Bouchet, "How Louisville can become a stronger and more equitable hub for AI and data economy jobs." (Washington: Brookings Institution, 2021).

34. Daniel Castro, "How can smaller cities join the growing AI economy?" (Washington: Government Technology, 2018).

Acknowledgments

The Metropolitan Policy Program at Brookings would like to thank the following for their generous support of this analysis and our metropolitan advanced economy work more broadly: the Howet Aerospace Foundation, Central Indiana Corporate Partnership and BioCrossroads, Derek Kaufman, Google, Microsoft, Mott Foundation, the Ralph C. Wilson, Jr. Foundation, Mario Morino, and Antoine van Agtmael. The program is also grateful to the Metropolitan Council, a network of business, civic, and philanthropic leaders that provides both financial and intellectual partners of the Program.

In addition, the authors are grateful for generous support from the Brookings Institution's Artificial Intelligence and Emerging Technology (AIET) Initiative, advanced by Brookings President John Allen.

The authors are also indebted to many colleagues who offered significant input with regard to the substantive development of the analysis.

Special thanks go to the following colleagues outside of Brookings for important insights or help: David Adams, Karen Bhatia, Miles Brundage, Nora Doherty, David Johnson, Paul Mitchell, Patrick Limbach, Pamela Mishkin, Nathan Ringham.

Within Brookings, the following staff offered significant substantive input: Alan Berube, Lavea Brachman, Annelies Goger, Chris Howie, Amy Liu, Rob Maxim, Chris Meserole, Joseph Parilla, Dinetta Parrott, Max Niles, Darrell M. West, and Yang You. In addition, the authors wish to thank Anthony Fiano, Michael Gaynor, David Lanham, and Erin Raftery for their editorial and communications expertise. Thanks to Luisa Zottis for layout and graphic design.

Photos: Shutterstock.

More information

About the Metropolitan Policy Program at Brookings

The Metropolitan Policy Program at Brookings delivers research and solutions to help metropolitan leaders build an advanced economy that works for all.

To learn more, visit www.brookings.edu/metro.

For more information

Mark Muro
Senior Fellow
Metropolitan Policy Program at Brookings
mmuro@brookings.edu

B | Metropolitan Policy Program
at BROOKINGS