Inclusive Science Policy and Economic Development in the 21st Century: The Case for Rural America

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Abstract:
While many of the original recommendations of Vannevar Bush's *Science—The Endless Frontier* report were implemented with great success in the twentieth century, the benefits of scientific innovation have not been fully realized in all corners of the United States. In particular, rural America persistently lags behind other locales in terms of scientific investment and economic development. In the coming decades, more place-conscious science policy will be needed to provide equal opportunities—and equal benefits—to all. This article highlights some of the current challenges relevant to science policy that are faced by rural America, with a specific emphasis on educational policy. The author offers recommendations for a more geographically inclusive science policy agenda and contends that rural equity should be a key priority for science policymakers in the United States.

I. Introduction

In the 1945 report, *Science, The Endless Frontier*, Vannevar Bush advocated for large-scale national investment in scientific research. Over the subsequent decades, the United States achieved many substantial milestones in basic and applied research and developed a sophisticated infrastructure for the advancement of scientific knowledge. Scientific innovations have contributed to astounding accomplishments in areas such as human health, technology, national defense, and economic development. However, these achievements have not yielded equal benefits to every corner of American society. While the advances wrought by effective science policy in the twentieth century are impressive, the differential benefits of scientific innovation and investment are particularly notable as points of demarcation between rural and urban America. Rural communities in the United States continue to strive toward equal access to scientific breakthroughs such as advanced telecommunications (i.e., broadband internet), quality health care, world-class education and high-paying jobs in science and technology. These domain areas, which I describe collectively as the innovation economy, are frequently used to gauge quality of life within the United States and beyond. And while science policy in the twentieth century was defined by the drive to advance scientific knowledge, the twenty-first century may well be defined by our ability to increase equitable access to these achievements.

In this article, I articulate some of the challenges of equitable science policymaking for rural America. In particular, I focus on the policy areas of education and economic development to highlight the ways in which twenty-first century science policy—often through the application of existing policy mechanisms—may be better positioned to serve rural constituents. Researchers in both policy and academic arenas use many differing definitions of rurality, which is important to note here. The most commonly used definitions throughout this paper are the U.S. Census Bureau Definition that defines a rural community as one with less than 2,500 residents or the broader U.S. Office of Management and Budget (OMB) definition for nonmetropolitan locales, which is used frequently

by the U.S. Department of Agriculture (USDA). Nonmetropolitan locales typically include those rural and small-town communities which lie outside of urbanized areas and do not have strong commuting ties to adjacent metropolitan centers (Cromartie 2019). These constructs are important to keep in mind, as defining rurality is a highly subjective process and different approaches may yield dramatically different constituent groupings for operationalizing public policy. In my own work, I often default to the OMB nonmetropolitan approach, as areas that are technically defined as "Small Towns" by the U.S. Census Bureau share many of the same economic, political, and demographic characteristics as those areas that the Census Bureau defines as "Rural." Readers may note each of these terms utilized in the paragraphs below as I have drawn upon a multitude of sources to argue for more geographically-inclusive science policymaking.

For well over a century, economic development in rural areas of the United States has relied heavily upon federal investments in scientific innovation through policies aimed at enhancing basic research, training scientific talent, and disseminating new discoveries to local communities. A useful starting point for this narrative is the passage of the Morrill Act of 1862, which ushered in a new era of growth in higher education. Through the sale of federal lands—lands previously seized from their indigenous occupants—the Morrill Act supported the establishment of new colleges "to teach such branches of learning as are related to agriculture and the mechanic arts" and "to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life." As time went on, the mission of these newly-formed land-grant universities grew more focused upon the tripartite goals of teaching, research, and service. The Hatch Act of 1887 and subsequent legislation further extended the land-grant initiative through the creation of experimental research stations and cooperative extension programs. This unique infrastructure was designed to develop and disseminate the latest scientific practices for agricultural production, disease prevention, and household economics to rural communities (Marcus 2015). Through both academic programs and the cooperative extension system, the burgeoning network of public universities became one of the primary vehicles of delivering an innovation economy to the masses in the United States.

Despite the tremendous benefits of the land-grant university system, the relationships between the federal government, public research universities, and rural America have always been fraught with cultural, political, and economic tensions (Bauerly 2016; Ron 2016). Agricultural life in the years following the Civil War was particularly challenging, as rural farmers faced low prices, deflation, growing competition from global markets, and monopoly control over distribution channels (Peters 2006). High rates of tenancy in rural areas, rural depopulation, soil exhaustion and other poor farming practices, as well as the "sheer drudgery" of rural farm life (Ziegler 2012, 83), increasingly captured the attention of social and political leaders across the United States. Around the turn of the twentieth century, Progressive reformers set out to understand why rural America seemed to be falling behind amidst a steadily urbanizing and industrializing society.

A Commission on Country Life championed by President Theodore Roosevelt set out to identify strategies to promote rural equity in a rapidly changing nation. "The country-life movement," wrote commission leader Liberty Hyde Bailey in 1915, "is the working out of the desire to make rural civilization as effective and satisfying as other civilization" (Bailey 1915, 1). Bailey saw a goal of the country life movement being to "balance up" society (Bailey 1915, 4) and improve both the economic vitality of agricultural work as well as what he referred to as the "social conditions in the open country" (Bailey 1915, 8). Bailey advocated for continued investment in agricultural colleges, more effective cooperative extension programs to promote scientific practices, enhanced collaboration between rural and urban stakeholders, and improvements to rural infrastructure. Although largely forgotten today, the Country Life movement of the early 1900s is viewed by some scholars as a significant historical moment that shaped rural life and federal policy for much of the twentieth century (Ziegler 2012). The Country Life Movement reflected a groundswell of activism surrounding rural life that bolstered efforts in subsequent years to increase national investments in infrastructure (e.g., roads, postal services), agricultural research, education, and access to financial capital in rural communities – with a

particular emphasis on educational reform (Bowers 1971).

In the present moment, it is interesting to reflect upon the parallels that still exist within national discourse about rural America. Just as the United States became a predominantly urban society early in the twentieth century, the world became predominantly urban early in the twenty-first century (Ritchie and Roser 2018; U.S. Census Bureau n.d.). With roughly nineteen percent of Americans still residing in rural locales (U.S. Census Bureau 2010), we continue to explore the ways in which scientific progress, economic change, national infrastructure, educational access, and social reforms foster inequity between rural and urban America. For instance, a 2017 analysis by the USDA found that manufacturing jobs were roughly twice as important for rural areas as for urban areas in terms of their contribution to rural earnings and employment, even as the number of rural manufacturing jobs fell by twenty-one percent between 2001 and 2015 (Low 2017). Likewise, growth in the digital economy and the expected rise of remote work opportunities, fueled in part due by the COVID-19 pandemic, are spurring new discussions about the future of work in rural locales. These disruptions add new urgency to calls from rural advocates for investment in important infrastructure such as broadband internet (Lindzon 2020) and other policy reforms designed to benefit rural constituents. Federal science policy has a particularly important role to play in this scenario, as demand for science and engineering workers in the United States is expected to continue growing and the ability to produce such talent—across all communities in the country—remains vital to global economic competitiveness (Burke 2019).

II. A closer look: Rural America, economic inequity, and the innovation economy

Given that rural locales may be characterized by the predominance of certain labor market sectors, such as education, health services, retail, or manufacturing, it is unsurprising that rural settings are highly susceptible to economic disruption. Notably, the agriculture sector is not represented on the list above, as the increasingly industrialized nature of farming and natural resource extraction has resulted in only one in ten rural workers being employed in farming, forestry, fishing, hunting, and mining (U.S. Census Bureau 2017). This fact alone is significant. It suggests that federal investment in agricultural research, which climbed as high as $18.6 billion in 2009 in the United States (USDA 2020), has limited ability to create new jobs in rural America and support the existence of a rural middle class. To cite one example, the National Agricultural Statistics Service found a seventy-three percent decline in self-employed and family farmworkers between 1950 and 2000. The number of hired farmhands also declined by 52 percent during this period (AgAmerica, 2020). This decline in participation by rural Americans in the agricultural economy signals the need to reimagine the policy systems that support rural stakeholders.

With these dynamics in mind, a useful case study can be formulated by examining the economic trends in rural America before and after the Great Recession of 2008. In 2007, the median income of rural households was $45,816, compared to $60,661 for urban households (USDA 2017). While lower costs of living in rural settings accounts for a portion of this divide, there is also significant regional variation in rural-urban income inequality across the U.S., with the South and West exhibiting the largest gaps (Kopparam 2020; USDA 2007). And while both urban and rural incomes declined dramatically after 2008, urban incomes have rebounded more steadily. The USDA reported that by 2019, average per capita income in the United States was at $56,490, compared to a per capita income of $42,993 in rural communities. Poverty rates remain persistently higher in rural settings: 15.3% versus 11.9% nationwide. Many rural settings continue to experience net outmigration, especially among educated workers (Cromartie and Viloria 2019; RHIhub 2021).

In addition to the concentration of rural workers in certain labor market sectors as described above, the years following the Great Recession also accelerated the presence of a "digital divide" between rural and urban America. Data from the Bureau of Labor Statistics shows that ninety-eight percent of new computer and math-related jobs created since 2007 were in metropolitan areas (Dunne and Knight 2020). In 2019, a report by the McKinsey Global Institute, The Future of Work in America, highlighted the stagnant growth in employment among rural areas since 2007. It indicated that communities defined as "Rural" and/or "Americana" had the lowest rates of

GDP in high-growth industries (23.5% or less) among all community types in the United States (Lund et al. 2019). The report stated:

"The economic performance of these [communities] has been diverging for decades, and that trend accelerated after the Great Recession. While all areas of the country lost employment during the downturn, job growth since then has been a tale of two Americas. Just twenty-five cities (megacities and high-growth hubs, plus their urban peripheries) have accounted for more than two-thirds of job growth in the last decade…By contrast, trailing cities have had virtually no job growth for a decade—and the counties of Americana and distressed Americana have 360,000 fewer jobs in 2017 than they did in 2007 (McKinsey Global Institute 2019)."

Figure 1 provides further information about the high-growth urban areas identified in the McKinsey report. Among these, just five cities—Boston, Los Angeles, New York, San Francisco, and San Jose—account for the majority of venture capital investment within the United States. With the global economy shifting heavily toward a greater emphasis on science and technology sectors, these patterns highlight significant structural barriers to the participation of rural Americans in the innovation economy and the growing startup ecosystem. Barriers include limited access to capital or a lack of broadband internet access (McKenna 2018; NCSL n.d.), placing many rural and small-town communities at a competitive disadvantage.

Megacities	High-Growth Hubs
Atlanta, GA	Austin, TX
*Boston, MA	Charlotte, NC
Chicago, IL	Denver, CO
Dallas, TX	Las Vegas, NV
Houston, TX	Minneapolis, MN
*Los Angeles, CA	Nashville, TN
Miami, FL	Orlando, FL
*New York, NY	Portland, OR
Philadelphia, PA	Raleigh, NC
Phoenix, AZ	San Antonio, TX
*San Francisco, CA	*San Jose, CA
Washington, DC	Seattle, WA
	Tampa, FL

Figure 1: Megacities and high-growth hubs (Lund et al. 2019). The five urban areas marked with an asterisk (*) accounted for more than 72% of the nation's total venture capital investment in 2016.

Aside from the limited economic diversity within rural communities, rural-urban income inequality, and other structural barriers to full participation in the innovation economy, access to high-quality educational experiences also remains a concern for many segments of rural America. As recently as 2019, the USDA reported that only twenty-one percent of rural residents overall held a bachelor's degree or higher. College completion rates were even lower among rural Black, indigenous, and Hispanic populations, of which only twelve percent or fewer held at least a bachelor's degree. By comparison, the USDA found roughly thirty-five percent of urban Americans held a bachelor's degree or higher and that urban educational attainment was increasing at a faster rate than rural educational attainment. These gaps are driven by a combination of factors, such as lower participation rates in postsecondary education and rural outmigration among those who do hold a four-year degree (Carr and Kefalas 2009; Koricich, Chen, and Hughes 2018; Petrin, Schafft, and Meece 2014).

Furthermore, of the 271 counties in the United States where twenty percent or more of the working-age population lack a high school degree or equivalent, 230 of these—approximately four out of five—are in rural areas (USDA 2019). Many of these counties are in the Southern United States and have an economic base in farming or manufacturing, and/or are persistent high-poverty areas. The majority of these counties with low educational attainment are also home to substantial (twenty percent or more) populations of African American or Hispanic residents. These factors highlight the complex interrelationship between rural geography, racial inequity, and economic development. Given the vital role education plays in preparing workers for twenty-first century career fields such as healthcare, information technology, engineering, or clean energy (BLS 2021; Entrepreneur 2021), these gaps in degree attainment should be viewed as a pressing issue relevant to federal science policy.

To further illustrate the role of the federal government in facilitating rural and small-town America's participation in the innovation economy, we may also examine the geographic distribution of research universities and related science and technology start-ups across the United States. The Science Coalition (2017) tracks federal funding for

basic research and reports on the economic impact of these investments. Among more than 300 companies emerging from federal research investment that the organization has tracked to date, the leading sectors include the biomedical field and companies working on technology or web products. As suggested by the McKinsey Global Institute's report (Lund et al. 2019), these high-growth industries are not likely to be anchored in rural communities. In fact, the Science Coalition reports that most research start-ups remain based near the universities from which they originated. Data on research universities in the United States—those most likely to receive large-scale federal investment—reinforce this argument, showing that only one of the 264 universities in the United States with high research activity is located in a rural locale. Even if the criteria are expanded to include both rural and small-town locales, more than ninety percent of universities with high research activity are based in urban and suburban settings (NCES 2021). Thus, an examination of the core infrastructure of innovation in the U.S. reveals additional ways in which rural locales are systematically disadvantaged from full participation in scientific innovation.

These data illustrate persistent economic challenges which have only grown more prominent after the massive economic disruptions of the Great Recession and the COVID-19 pandemic (Kopparam 2020; Kusmin 2017; Mueller et al. 2021). There is some evidence that the disruptions caused by COVID-19, such as increasing worker mobility due to expanded teleworking opportunities (Johanson 2021), may contribute positively to rural economies. However, it remains to be seen whether these recent trends will result in sustained and/or widespread change across the economic landscape. The COVID-19 pandemic has also renewed concerns that rural-urban social divisions within the United States are manifested in part by an increasing mistrust of science within rural communities (Krause et al. 2019), a development that may reflect the larger sense of alienation from the innovation economy that rural Americans have experienced (Barkley 1995; Hart 2018; Kight and Bartz 2019). These facts paint a disturbing picture of the challenges facing rural America and the potential role of science policy in addressing such inequities. Given a rural landscape hindered by persistent economic inequality, substantial structural barriers to participation, and communities that are falling further behind in economic competitiveness, federal policymakers must deploy a more geographically inclusive approach to scientific innovation moving forward.

III. Barriers to STEM participation in rural schools

As an illustration of the connections between education and science policy, let us further explore the barriers to STEM participation within rural K-12 schools. These challenges include the strength of STEM curricular offerings, the availability of qualified STEM instructors, the supply of STEM jobs in rural locales, and the funding streams available to support STEM talent development in rural settings.

For example, educational research has consistently shown that access to high-quality STEM training, such as Advanced Placement (AP) courses during high school, is more difficult to provide in rural settings. In part, this issue stems from having a lower density of qualified students to enroll in such courses, as well as the challenges associated with securing instructors who are qualified to teach advanced STEM subjects. Researchers have also found that limited access to AP coursework may result in rural students being unable to "experience college-level coursework, earn college credit while in high school, or develop an advantage in the selective admissions process" for college (Gagnon and Mattingly 2016, 278). Possible solutions include the use of targeted funds to train more qualified AP instructors in rural settings, cover the costs of the AP examinations for rural students, or coordinate state-sponsored summer AP programs for students who do not have localized access to such courses.

The limited availability of STEM jobs in rural locales may also be a barrier to engagement in STEM career fields. Research on the formation of career self-concepts among adolescents suggests that professional role models may be useful in inspiring interest in certain occupations. Thus, the lack of personal exposure to engineers, scientific researchers, or computer programmers could make it more challenging for rural students to envision themselves in such fields (Ali and Saunders 2009). Even for those who are interested in STEM-related occupations, entry into some professions, such as medicine, may be more challenging for students without personal connections in these areas. An additional challenge is the conflict between staying

home or moving away as rural students must often confront the reality that their career interests will lead them away from their communities (Carr and Kefalas 2009; Petrin, Schafft, and Meece 2014). Rural students who have an interest in STEM may opt for a different career path or shift their objectives toward more locally viable alternatives. Such barriers to STEM careers may function in a cumulative manner to gently (or not so gently) nudge rural students away from STEM occupations. A recent study found that high school students in nonmetropolitan settings were often interested in STEM occupations at rates greater than their metropolitan counterparts, but experienced increased risks of not enrolling in college and enrolling less frequently in four-year degree-granting institutions (Crain and Webber 2021). Even though geography alone may not explain such educational outcomes, rural students often live in settings where overcoming high-risk factors such as being low-income, a racial minority, or a first generation college student is even more difficult. In this sense, targeted resources for rural areas could help to better meet the needs of such populations.

Finally, researchers have also outlined the barriers faced by rural communities in accessing additional funding for education. Federal Education Policy in Rural America (Johnson, Mitchel, and Rotherham 2014) argued that most federal education policies are not designed explicitly for rural schools but are nevertheless applied to rural locales through a place-neutral (and often inherently urban-centric) policymaking approach. The researchers found that funding formulas for at-risk students differed by locale, with rural schools typically receiving fewer per-pupil funds. Furthermore, the added expenses associated with federal grants, such as budgeting, reporting, or grant administration, as well as the frequent use of a reimbursement model (which requires schools to provide services up front before receiving funds), serve as potential barriers to funding access for small rural districts. In some cases, the time and energy needed to apply for additional funding support is cost prohibitive for rural schools with limited administrative staff. Other approaches to grant-making, such as the requirement for rural communities to provide matching funds for grant allocations, are similarly limiting (Ajilore and Willingham 2020).

IV. Advancing rural-focused science policy and investment

While educational pathways represent only one segment of the innovation economy influenced by science policy, the examples shown here of the curricular, economic, and administrative barriers to widening STEM participation illustrate the larger challenges within rural America. Federal science policy can and must play a role in addressing these inequities in the future, in part through the development of a more comprehensive and place-conscious policy agenda. Below are several proposals for how such an agenda might look:

i. Place greater emphasis on sustained, long-term investment in rural communities.

The current model for funding basic research through agencies such as the National Science Foundation is often centered around the use of short-run experimental programs with average grant durations of less than three years (National Science Foundation 2017). Typically, such grants also include an outreach component that requires investigators to engage with an underserved (i.e., rural, low-income, or racially marginalized) community. Although it is certainly beneficial to pilot new models of scientific research and STEM education, rural communities and small towns could benefit far more from sustained engagements based upon established approaches to STEM education. Short-run educational outreach and training programs, for example, require rural educators to devote limited time and resources toward activities with a relatively narrow long-term impact. More programs that focus specifically on rural communities are also necessary to provide targeted models of training, research, and development.

ii. Centralize coordination to address rural challenges within the federal government.

Rural development plays an important role within many public initiatives, with multiple agencies such as the USDA, the Department of Education, HUD, and the FCC awarding funds to rural communities. However, such investment is often uncoordinated and may be enhanced by efforts to break down administrative silos within the federal government. Federal investments in basic research could be adjusted to become more inclusive of rural communities (e.g., more allocations to rural-serving colleges and universities) alongside more

coordinated economic development efforts by agencies such as the USDA and FCC. Just as the Country Life movement sparked coordinated investment in rural America in the early 1900s, more coordinated delivery and monitoring of rural policy initiatives at the federal level could be highly beneficial in the coming decades. The concept of a comprehensive "Rural America New Deal" (Marx 2020) exemplifies just one approach that could be utilized to deliver the innovation economy to rural and small-town settings through broad investments in STEM education, workforce training, research, and job creation.

iii. Deploy simplified funding mechanisms and provide more direct support to rural schools, community colleges, regional universities, or other rural-serving institutions.

For many rural communities and rural-serving organizations, the need to compete for limited federal funds and meet complex reporting requirements curtails their ability to seek financial support. One strategy to foster more inclusive growth is to invest more in established institutions, especially rural community colleges or regional four-year universities. Funding vehicles such as block grants could provide greater flexibility, enhance access to federal support, and help to avoid exclusionary practices such as the requirement for matching funds. Funding made available at the regional level could foster sustainable economic growth across numerous rural communities and small towns, which may be ill-equipped to compete individually for federal awards. Investments in postsecondary institutions that serve rural areas may not only help to directly jumpstart scientific innovation in such areas, but may also contribute to the success of K-12 educational systems by training qualified teachers and building STEM career aspirations among students through the cultivation of diverse local economies.

iv. Invest in rural startups, particularly in high-growth fields.

As efforts progress at the state, regional, and federal levels to expand rural broadband internet access, it is also necessary to develop policy frameworks that promote the creation of more science or technology-based startups in rural settings. Tax incentives, partnerships with rural colleges or workforce development programs, rural incubators or startup seed grants may all be viable options for targeting further investment and diverse job growth in rural communities and/or underdeveloped regional hubs.

Although none of these proposals to enhance rural education and economic development are particularly ground-breaking, I argue here that these efforts have never been explicitly linked to the broader national science policy agenda in the United States. There is an important need to recalibrate the conversation about science policy and rural development—shifting the focus away from an emphasis on agriculture toward a more comprehensive effort to bolster rural inclusion in other areas of scientific achievement. Vannevar Bush argued for just such an approach. Acknowledging the nation's history of meeting new challenges, Bush in 1945 contended that "…the frontier of science remains. It is in keeping with the American tradition—one which has made the United States great—that new frontiers shall be made accessible for development by all American citizens." In terms of the thriving innovation economy which we all envision for our great nation, the next frontier of science policy could very well be rural inclusion. Uplifting every corner of the United States through scientific discovery will cement the role of the United States as a world leader in knowledge creation, economic competitiveness, and quality of life.

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