

# TARGETING FEDERAL LABORATORIES AS A CATALYST FOR PRIVATE INVESTMENT IN RESEARCH AND DEVELOPMENT

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ARIZONA STATE UNIVERSITY

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## INTRODUCTION

The attraction of a federal research laboratory to Arizona as a strategic economic development initiative of the Arizona Economic Resource Organization (AERO) can be justified based on the literature cited below, the relationship of federally funded research and development centers (FFRDCs) to broader measures of research and development (R&D) and prosperity, and the implementation of this strategy elsewhere. A primary objective of attracting a federal research facility is to help create a climate that is conducive to private-sector economic development, especially related to research and development. On a purely cost-benefit basis, the pursuit of a federal lab has strong appeal since the benefits largely will accrue within Arizona while a considerable portion of the costs conceivably will be borne by the federal government.

## BACKGROUND

An extensive academic literature links the pace of private investment in R&D in a region to the amount and quality of public research infrastructure in the region. The linkage is based on knowledge spillovers from the public activity, the development of a research foundation that mutually attracts high-quality businesses and researchers, and the availability of qualified workers, and often faculty consultants, in part due to the ongoing public research activity.

In a report produced for Science Foundation Arizona (SFAz) in 2007, economists from the University of Arizona and Arizona State University applied empirical estimates from Jaffe et. al. (1989, 1993, 2002) to estimate that the rate of return — measured in induced private-sector R&D activity — to an investment in publicly supported research activity was on the order of 4 to 1. Zucker and Darby (2007), in an extensive analysis of the linkages between highly regarded scientists and regional economic impact, find that it is the physical presence of the star scientists, rather than the embodied knowledge of their work, that is the catalyst for economic activity. Abramovsky et. al. (2007) report results in the prestigious *Economic Journal* that identify a clear correlation between the location of research facilities in Britain and the location of quality academic research departments. The British evidence is interesting since it is based on detailed establishment-level data rather than aggregate information or survey data on the location of private-sector R&D.

## THE LANDSCAPE

The master list of the 38 FFRDCs is shown in Table 1. One of the 38 is located in Puerto Rico and one has two locations, resulting in 38 locations within the continental United States. The facilities are quite concentrated with 10 located in the Washington DC metropolitan area and eight in California. Arizona has one: the National Optical Astronomy Observatories, based in Tucson.

Table 2 provides the most recent information on public and private R&D expenditures by state. The states with at least one federal FFRDC are noted in bold. Other measures included in the table are total R&D as a percentage of Gross Domestic Product (GDP) by state, per capita GDP by state, and growth in real per capita GDP over the 1997-to-2005 period. The rank among the 50 states and the District of Columbia also is displayed for each of these measures.

The table illustrates that R&D is quite concentrated, with 22 percent of the nation's total R&D and industry R&D conducted in California, which also ranks high (sixth among the states) in

## TABLE 1

### MASTER GOVERNMENT LIST OF FEDERALLY FUNDED R&D CENTERS

(The FFRDC is in bold; the administrator of each FFRDC appears in parentheses)

#### Department of Defense

##### Office of the Secretary of Defense

Administered by other nonprofit institutions: **[1]**

- **Institute for Defense Analyses Studies and Analyses Federally Funded Research and Development Center** (Institute for Defense Analyses), Alexandria, VA
- **National Defense Research Institute** (RAND Corp. **[2]**), Santa Monica, CA
- **C3I Federally Funded Research & Development Center** (MITRE Corp.), Bedford, MA, and McLean, VA

##### National Security Agency

Administered by other nonprofit institutions: **[1]**

- **Institute for Defense Analyses Communications and Computing Federally Funded Research and Development Center** **[3]** (Institute for Defense Analyses), Alexandria, VA

##### Department of the Navy

Administered by other nonprofit institutions: **[1]**

- **Center for Naval Analyses** (The CNA Corporation), Alexandria, VA

##### Department of the Air Force

Administered by universities and colleges: **[4]**

- **Lincoln Laboratory** (Massachusetts Institute of Technology), Lexington, MA

Administered by other nonprofit institutions: **[1]**

- **Aerospace Federally Funded Research and Development Center** (The Aerospace Corporation), El Segundo, CA
- **Project Air Force** (RAND Corp. **[2]**), Santa Monica, CA

##### Department of the Army

Administered by universities and colleges: **[4]**

- **Software Engineering Institute** **[5]** (Carnegie Mellon University), Pittsburgh, PA

Administered by other nonprofit institutions: **[1]**

- **Arroyo Center** (RAND Corp. **[2]**), Santa Monica, CA

#### Department of Energy **[6]**

Administered by industrial firms:

- **Idaho National Laboratory** (Battelle Energy Alliance, LLC) **[7]**, Idaho Falls, ID
- **Los Alamos National Laboratory** **[8]** (Los Alamos National Security, LLC), Los Alamos, NM
- **Sandia National Laboratories** (Sandia Corporation, a subsidiary of Lockheed Martin Corp.), Albuquerque, NM
- **Savannah River National Laboratory** (Westinghouse Savannah River Co.), Aiken, SC **[17]**

Administered by universities and colleges: **[4]**

- **Ames Laboratory** (Iowa State University of Science and Technology), Ames, IA
- **Argonne National Laboratory** (University of Chicago), Argonne, IL
- **Ernest Orlando Lawrence Berkeley National Laboratory** (University of California), Berkeley, CA
- **Fermi National Accelerator Laboratory** (Universities Research Association, Inc.), Batavia, IL
- **Lawrence Livermore National Laboratory** (University of California), Livermore, CA
- **Princeton Plasma Physics Laboratory** (Princeton University), Princeton, NJ
- **Stanford Linear Accelerator Center** (Leland Stanford, Jr., University), Stanford, CA
- **Thomas Jefferson National Accelerator Facility** (Jefferson Science Associates, LLC), Newport News, VA **[18]**

Administered by other nonprofit institutions: **[1]**

- **Brookhaven National Laboratory** **[9]** (Brookhaven Science Associates, Inc.), Upton, Long Island, NY
- **National Renewable Energy Laboratory** **[10]** (Midwest Research Institute; Battelle Memorial Institute; Bechtel National, Inc.), Golden, CO
- **Oak Ridge National Laboratory** **[11]** (UT-Battelle, LLC), Oak Ridge, TN
- **Pacific Northwest National Laboratory** (Battelle Memorial Institute), Richland, WA

(continued)

**TABLE 1 (continued)**  
**MASTER GOVERNMENT LIST OF FEDERALLY FUNDED R&D CENTERS**

**Department of Health and Human Services** 

National Institutes of Health

Administered by industrial firms:

- [National Cancer Institute at Frederick \[12\]](#) (Science Applications International Corp.; Charles River Laboratories, Inc.; Data Management Services, Inc.; Wilson Information Services, Inc.), Frederick, MD

**Department of Homeland Security** 

Under Secretary for Science & Technology

Administered by other nonprofit institutions: [\[1\]](#)

- [Homeland Security Institute \[13\]](#) (Analytic Services, Inc.), Arlington, VA
- [National Biodefense Analysis & Countermeasures Center \[19\]](#) (Battelle National Biodefense Institute), Frederick, MD

**National Aeronautics and Space Administration** 

Administered by universities and colleges: [\[4\]](#)

- [Jet Propulsion Laboratory](#) (California Institute of Technology), Pasadena, CA

**National Science Foundation** 

Administered by universities and colleges: [\[4\]](#)

- [National Astronomy and Ionosphere Center](#) (Cornell University), Arecibo, PR
- [National Center for Atmospheric Research](#) (University Corporation for Atmospheric Research), Boulder, CO
- [National Optical Astronomy Observatories \[14\]](#) (Association of Universities for Research in Astronomy, Inc.), Tucson, AZ
- [National Radio Astronomy Observatory](#) (Associated Universities, Inc.), Charlottesville, VA

Administered by other nonprofit institutions: [\[1\]](#)

- [Science and Technology Policy Institute \[15\]](#) (Institute for Defense Analyses), Washington, DC

**Nuclear Regulatory Commission** 

Administered by other nonprofit institutions: [\[1\]](#)

- [Center for Nuclear Waste Regulatory Analyses](#) (Southwest Research Institute), San Antonio, TX

**Department of Transportation** 

Federal Aviation Administration

Administered by other nonprofit institutions: [\[1\]](#)

- [Center for Advanced Aviation System Development](#) (MITRE Corp.), McLean, VA

**Department of the Treasury** 

Internal Revenue Service

Administered by other nonprofit institutions: [\[1\]](#)

- [Internal Revenue Service \(IRS\) Federally Funded Research and Development Center \[16\]](#) (Center for Enterprise Modernization, MITRE Corp.), McLean, VA

(continued)

**TABLE 1 (continued)**  
**MASTER GOVERNMENT LIST OF FEDERALLY FUNDED R&D CENTERS**

**Footnotes** 

- [1]** That is, other than universities and colleges.
- [2]** The following portions of the RAND Corporation are FFRDCs: National Defense Research Institute (formerly Defense/Office of the Joint Chiefs of Staff), Project Air Force, and the Arroyo Center.
- [3]** Although the Institute for Defense Analyses Communications and Computing FFRDC has been in existence since 1956, the Department of Defense added it to the Master Government List of FFRDCs for the first time in October 1995.
- [4]** Includes university consortia.
- [5]** In June 1997, Office of the Secretary of Defense became the sponsor of the Software Engineering Institute (SEI). The previous sponsor was Defense Advanced Research Projects Agency. In December 2004, Department of the Army became the sponsor of SEI.
- [6]** The Department of Energy removed Oak Ridge Institute for Science and Education from the Master Government List of FFRDCs on Feb. 22, 1999.
- [7]** On February 1, 2005, the Idaho National Engineering and Environmental Laboratory was renamed the Idaho National Laboratory (INL). Also, INL's administrator, Bechtel BWXT Idaho, LLC, was renamed Battelle Energy Alliance, LLC.
- [8]** On June 1, 2006, Los Alamos National Laboratory acquired a new industrial firm administrator (Los Alamos National Security, LLC).
- [9]** On March 1, 1998 Brookhaven National Laboratory acquired a new nonprofit administrator (Brookhaven Science Associates, Inc.). The previous administrator was a university consortium.
- [10]** In September 1991, the name was changed from Solar Energy Research Institute.
- [11]** On April 1, 2000, Oak Ridge National Laboratory acquired a new nonprofit administrator (UT-Battelle, LLC). The previous administrator was the industrial firm Lockheed Martin Energy Research Corp.
- [12]** In 2000, the name was changed from NCI Frederick Cancer Research and Development Center. It continues to be an FFRDC.
- [13]** On April 26, 2004, the Homeland Security Institute was created.
- [14]** Since February 1984, this center includes three former FFRDCs: Cerro Tololo Inter-American Observatory, Kitt Peak National Observatory and the National Solar Observatory (formerly Sacramento Peak Observatory).
- [15]** On October 1, 1998, the Critical Technologies Institute was renamed the Science and Technology Policy Institute (STPI). As of December 1, 2003, RAND Corp. was replaced by the Institute for Defense Analyses as STPI's administrator.
- [16]** In October 1998, the Tax Systems Modernization Institute (IIT Research Institute) Lanham, MD, contract expired. TSMI was replaced with Internal Revenue Service (IRS) Federally Funded Research and Development Center administered by the MITRE Corp. in McLean, VA.
- [17]** The Savannah River National Laboratory changed its name and operating contractor to Washington Savannah River Co. on December 8, 2005. Before that, its name was the Savannah River Technology Center and the operating contractor was Westinghouse Savannah River Co.
- [18]** Jefferson Science Associates is a partnership of the Southeastern Universities Research Association (SURA), a consortium of sixty universities and the Computer Sciences Corporation (CSC). The effective date when SIRA added the CDC as a partner was April 14, 2006.
- [19]** The Department of Homeland Security established this new FFRDC on December 20, 2006. Its Web site has not been set up yet.

Source: National Science Foundation.

R&D as a share of GDP. Table 2 also reveals that states with research laboratories tend to have high amounts of industrial R&D. Indeed the 18 states with at least one FFRDC have 66 percent of total industry R&D. Moreover, as a reflection of the concentration exhibited by industrial R&D, the seven states with at least two facilities have 37 percent of total industry R&D.

The academic literature indicates that investments in research and development promote economic prosperity. The states ranked highly in industrial research intensity generally also have high standards of living, as measured by gross state product per capita. However, exceptions exist. Michigan is the most highly R&D intensive state but its recent economic performance is lagging the nation. Since a large portion of the private R&D in Michigan is related to the auto industry, this is a good illustration of the pitfalls of investing in a nondiversified manner. However, this investment in the auto industry may reap further rewards as Michigan transitions from its reliance on industrial manufacturing to greater reliance on R&D for the entire auto industry. Toyota's recent selection of Ann Arbor for their North American R&D headquarters illustrates the results of this strategy.

### **THE COLORADO STRATEGY**

Colorado, and especially the Metro Denver Economic Development Corporation, promotes federal labs and research centers as a part of their economic development strategy. The information in Figure 1 illustrates that the NSF tabulation of FFRDCs in Table 1 does not include various research centers, such as Boulder's National Institute of Standards and Technology, nor the National Oceanic and Atmospheric Administration. As seen in Figure 1, a significant federally supported research infrastructure is present in Colorado, with 4,500 jobs and \$720 million in total economic impact attributed to the presence of federal labs and related academic research centers. The economic development strategy touts this as an asset. The Denver Metro Economic Development Corporation aims to leverage the presence of the labs to foster the image of Denver and Colorado as a strong competitor for knowledge-based jobs.

Colorado attracted 54 percent more industry R&D than Arizona in 2005, despite a gross product approximately equal to that of Arizona, as seen in Table 2. Per capita GDP in Colorado was about 29 percent greater than that of Arizona. Hence, while the economies of Arizona and Colorado were approximately equal in size in 2005, the standard of living in Colorado was considerably higher. A host of factors likely contribute to this disparity in the standard of living, including differences in educational attainment.

**TABLE 2**  
**RESEARCH AND DEVELOPMENT FUNDING AND GROSS DOMESTIC PRODUCT, 2005**

	Research & Development			Gross Domestic Product						
	Number of FFRDC	Total	Industry	Total	R&D Share of GDP	Rank	Per Person	Rank	Per Person, 1997-2005	Rank
United States	38	\$226,159	\$204,250	\$12,372,850	1.8%		\$41,729		1.9%	
Alabama	0	1,417	698	151,342	0.9	30	33,274	44	2.1	20
Alaska	0	32	30	39,394	0.1	51	59,395	3	-0.6	51
<b>Arizona</b>	1	2,980	2,711	212,312	1.4	20	35,665	40	2.4	13
Arkansas	0	271	262	87,004	0.3	43	31,345	49	1.7	27
<b>California</b>	8	50,683	45,618	1,616,351	3.1	6	44,707	13	2.9	6
<b>Colorado</b>	2	4,299	4,168	214,337	2.0	12	45,963	10	2.1	19
Connecticut	0	7,885	6,442	193,496	4.1	3	55,274	4	1.6	35
Delaware	0	1,511	1,490	56,731	2.7	9	67,397	2	1.7	29
<b>District of Columbia</b>	1	166	93	82,628	0.2	48	141,961	1	2.7	9
Florida	0	4,164	2,974	666,639	0.6	34	37,519	35	2.4	14
Georgia	0	2,282	2,226	358,365	0.6	33	39,240	28	0.9	45
Hawaii	0	168	122	54,773	0.3	44	43,017	18	1.3	40
<b>Idaho</b>	1	642	635	45,891	1.4	21	32,106	47	2.9	5
<b>Illinois</b>	2	9,712	9,506	555,599	1.7	16	43,524	15	1.3	38
Indiana	0	4,610	4,327	236,357	2.0	13	37,720	34	1.6	36
<b>Iowa</b>	1	1,039	1,029	117,635	0.9	31	39,668	24	2.1	22
Kansas	0	1,993	D	105,228	1.9	14	38,290	32	1.8	24
Kentucky	0	660	650	138,616	0.5	38	33,220	45	0.5	49
Louisiana	0	300	278	180,336	0.2	49	40,009	23	0.7	48
Maine	0	350	331	44,906	0.8	32	34,066	43	1.4	37
<b>Maryland</b>	2	3,706	2,452	244,447	1.5	18	43,732	14	2.4	12
<b>Massachusetts</b>	2	13,342	10,788	320,050	4.2	2	49,748	7	2.8	8
Michigan	0	16,752	16,548	372,148	4.5	1	36,843	38	0.5	50
Minnesota	0	6,340	6,053	231,437	2.7	8	45,143	12	2.1	21
Mississippi	0	194	147	79,786	0.2	46	27,432	51	0.7	47
Missouri	0	2,602	2,523	215,073	1.2	27	37,096	36	0.9	46
Montana	0	77	71	29,915	0.3	45	32,004	48	2.3	15
Nebraska	0	407	400	72,242	0.6	36	41,089	20	1.7	28
Nevada	0	382	365	110,158	0.3	42	45,665	11	1.0	44
New Hampshire	0	1,435	D	54,119	2.7	10	41,413	19	2.5	11
<b>New Jersey</b>	1	13,214	12,902	427,654	3.1	7	49,138	8	1.6	34
<b>New Mexico</b>	2	405	278	69,692	0.6	35	36,185	39	2.1	17
<b>New York</b>	1	9,474	8,819	961,385	1.0	29	49,772	6	2.9	7
North Carolina	0	5,158	5,051	350,700	1.5	19	40,438	22	1.7	30
North Dakota	0	104	D	24,935	0.4	40	39,292	26	3.1	3
Ohio	0	5,900	5,445	442,243	1.3	23	38,554	31	1.2	41
Oklahoma	0	422	401	121,558	0.3	41	34,305	42	1.6	33
Oregon	0	3,252	3,223	141,831	2.3	11	38,977	30	2.9	4
<b>Pennsylvania</b>	1	8,846	8,640	486,139	1.8	15	39,188	29	1.8	23



	Number of FFRDC	Research & Development		Gross Domestic Product						
		Total	Industry	Total	R&D share of GDP	Rank	Per Person	Rank	Per Person, 1997-2005	Rank
Rhode Island	0	\$1,387	\$ D	\$43,623	3.2%	5	\$40,633	21	2.2%	16
<b>South Carolina</b>	1	1,402	1,364	140,088	1.0	28	32,986	46	1.1	43
South Dakota	0	68	66	30,541	0.2	47	39,414	25	3.2	2
<b>Tennessee</b>	1	1,246	1,150	224,995	0.6	37	37,778	33	1.6	32
<b>Texas</b>	1	12,438	11,579	989,333	1.3	25	43,149	16	1.7	31
Utah	0	1,234	1,036	88,364	1.4	22	35,483	41	1.1	42
Vermont	0	360	338	23,056	1.6	17	37,044	37	3.3	1
<b>Virginia</b>	9	4,379	2,683	350,692	1.2	26	46,361	9	2.7	10
<b>Washington</b>	1	9,736	9,555	271,381	3.6	4	43,132	17	1.7	26
West Virginia	0	242	D	53,091	0.5	39	29,266	50	1.3	39
Wisconsin	0	2,729	2,660	216,985	1.3	24	39,255	27	1.7	25
Wyoming	0	30	29	27,246	0.1	50	53,550	5	2.1	18
Undistributed funds		3,731	3,636							

D = data withheld to avoid disclosing operations of individual companies.

Source: National Science Foundation, Division of Science Resources Statistics, Survey of Industrial Research and Development: 2005 and U.S. Department of Commerce, Bureau of Economic Analysis

## FIGURE 1 METRO DENVER ECONOMIC DEVELOPMENT CORPORATION WEBSITE



[www.metrodenver.org](http://www.metrodenver.org)

### Federal Labs

#### ***A center for the world's best research and researchers.***

Groundbreaking research on the shrinking polar ice caps. Development of hydrogen fuel cells that could someday power the world's cars. Creation of a turbulence-detecting system to minimize worldwide flight delays. These are just some of the research projects taking place at federal laboratories and research institutes based in Metro Denver.

Colorado has one of the highest concentrations of federally funded science and research labs in the nation. Employing more than 4,500 scientists and engineers and generating an estimated \$720 million annual economic impact to the region, these federal labs have contributed greatly to the evolution of Metro Denver's high-tech industries. The labs also stimulate significant tech transfer opportunities among higher educational and area companies in critical areas such as climate research, space science, and renewable energy development.

#### **Major federal labs and research centers**

- [National Oceanic and Atmospheric Administration \(NOAA\)](#) - the federal government's top agency for monitoring our climate, the space environment, and ocean resources (Boulder)
- [National Renewable Energy Laboratory \(NREL\)](#) - the nation's primary laboratory for renewable energy and energy efficiency R&D (Golden)
- [National Institute of Standards and Technology \(NIST\)](#) - promotes U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology (Boulder)
- [University Corporation for Atmospheric Research \(UCAR\)](#) - dedicated to exploring and studying our atmosphere and its interaction with the sun, oceans, biosphere, and society (Boulder)
- [National Center of Atmospheric Research \(NCAR\)](#) - managed by UCAR, is a National Science Foundation R&D Center (Boulder)
- [Cooperative Institute for Research in the Atmosphere \(CIRA\)](#) - directs research in the atmospheric sciences into practical applications in weather and climate (Fort Collins)
- [Cooperative Institute for Research in Environmental Sciences \(CIRES\)](#) - dedicated to research targeted at all aspects of Earth System Science and communicating its findings to the global scientific community (Boulder)

Source: Metro Denver Economic Development Corporation.

## REFERENCES

Abramovsky, L., Harrison, R. and Simpson, H. "University Research and the Location of Business R&D," *The Economic Journal*, 117 (March 2007): C114-C141.

Jaffe, A. "Real Effects of Academic Research," *The American Economic Review*, 79 (1989): 957-970.

Jaffe, A., Trajtenberg, M., and Henderson, R. "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations," *Quarterly Journal of Economics*, 108 (1993): 577-598.

Jaffe, A. and Trajtenberg, M. *Patents, Citations, and Innovations: A Window on the Knowledge Economy*, The MIT Press, 2002.

Zucker, L., Darby, M. *Star Scientists, Innovation and Regional and National Immigration*, NBER working paper no. 13547, October 2007.