

Greater Cleveland's R&D Economy

Greater Cleveland Partnership

April 3, 2023



Executive Summary – Greater Cleveland's R&D Economy

An interrelated network of research facilities at companies, hospitals and clinics, research centers from academic institutions and NASA Glenn Center constitutes the Greater Cleveland's R&D economy.

During 2021, this network spent ~\$ 3.7 billion in Greater Cleveland R&D activities. Companies led R&D expenditure (\$2,530 M), followed by academic institutions (\$575 M), NASA Glenn Center (\$557 M), and hospitals and clinics (\$505 M).

- **R&D expenditure by companies in the region is led by automotive, machinery, and chemical manufacturing firms*, and accounts for 1.3% of the regional GDP.** This figure is 1.5% for Ohio and 2.3% for the United States. R&D expenditure in the region has been growing faster than in Ohio (25% between 2016 and 2019 versus 20%).
- **Research efforts at universities are highly focused on Life Sciences (75% of R&D expenditure) followed by engineering and physical sciences.**
- **R&D activities at hospitals and clinics have strong focus areas in cardiology, cancer, immunotherapy, and neurology.**
- **NASA Glenn R&D is focused on physical sciences, power and propulsion, and communications services**

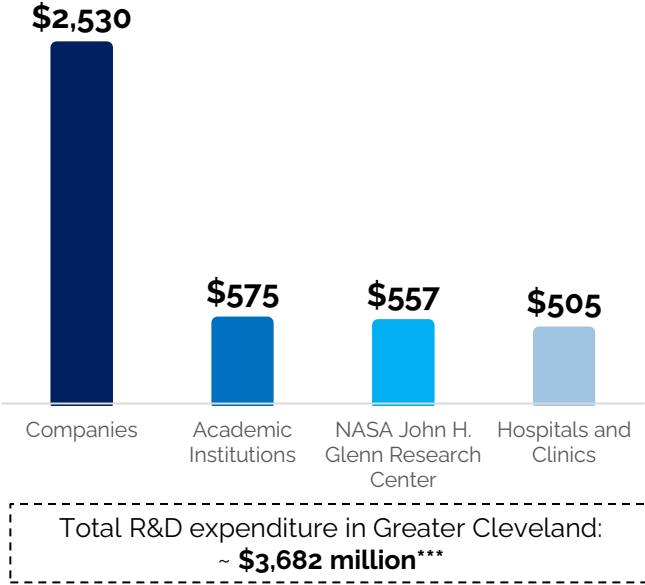
Between 2017 and 2021, more than 8,500 patents were granted to Greater Cleveland's headquarters or subsidiaries. Rockwell Automation Technologies, Goodyear Tire & Rubber, Eaton and Case Western led the patent count.

Between 2017 and 2021, 350+ companies in the region raised ~\$1.9 billion in venture capital. During the same period, 111 companies received \$151 million in SBIR/STTR awards. Leading sectors include healthcare, IT, and business-to-consumer.

The economic specialization of Greater Cleveland mirrors regional R&D economy, with sectors with high R&D expenditure showing strong location quotients. Sectors with the strongest performance in terms of specialization and employment growth over the last decade include plastic and rubber products manufacturing, machinery manufacturing, transportation equipment manufacturing, hospitals, and educational services.

R&D centers in Greater Cleveland invested ~\$ 3.7 billion in R&D activities in 2021; 69% of those investments came from companies

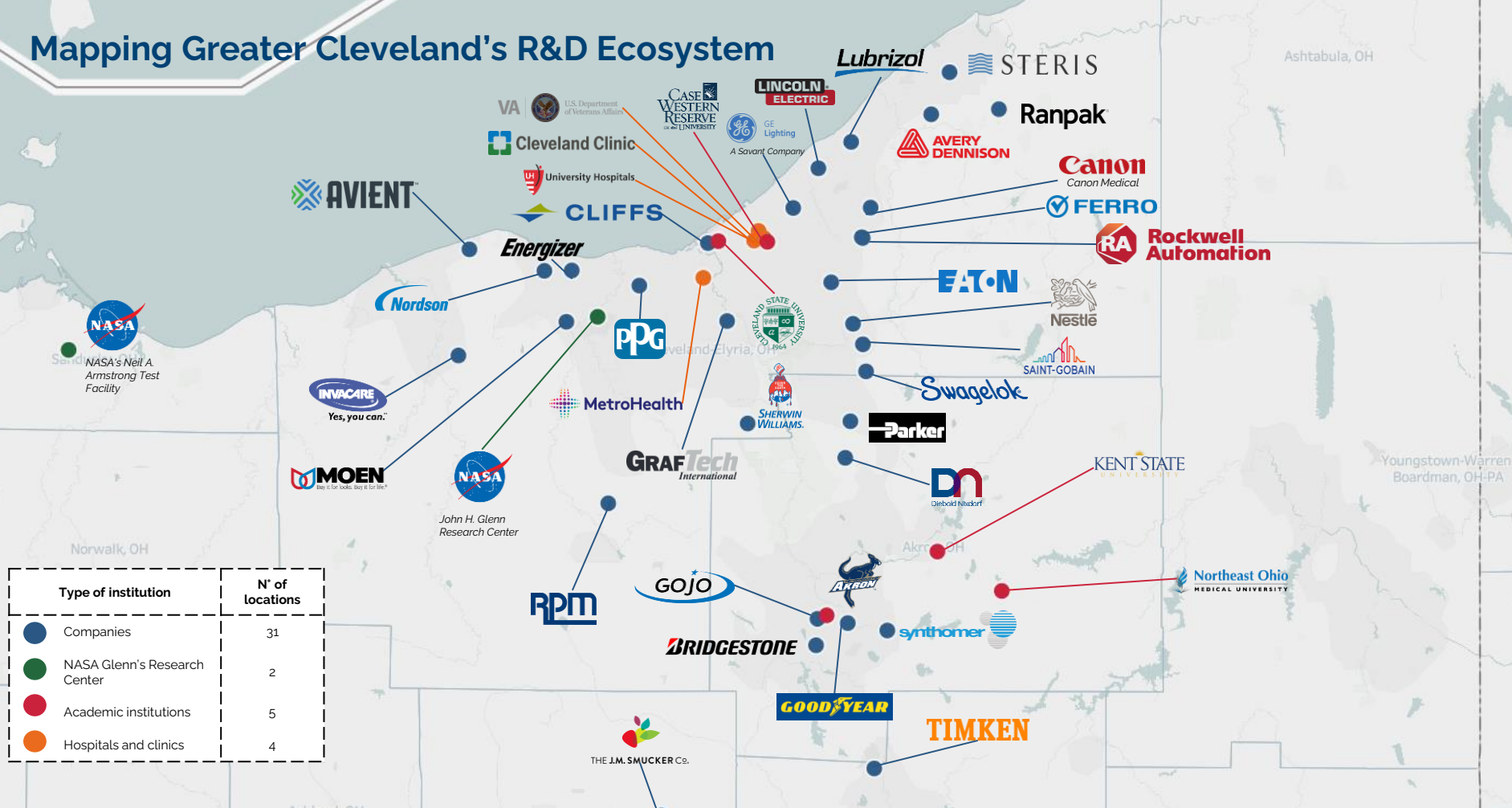
R&D expenditure by type of institution in Greater Cleveland. In millions, 2021*.



<p>Companies</p> <p>Automotive Parts Mfg. Machinery Mfg. Chemical Mfg. Paper Mfg.</p>				
<p>Academic institutions</p> <p>  \$ 422 M  \$ 71 M  \$ 50 M  \$ 17 M  \$ 14 M </p>				
<p>NASA John H. Glenn Research Center**</p> <p>   </p>				
<p>Hospitals and Clinics</p> <p>  Cleveland Clinic \$ 315 M***  University Hospitals Cleveland Medical Center \$ 170 M***  VA \$ 15 M  U.S. Department of Veterans Affairs  Metro Health \$ 5 M </p>				

Notes: (*) Greater Cleveland includes 3 MSAs: Cleveland-Elyria MSA, Akron MSA, and Canton-Massillon MSA. The information is for 2021, except for companies where data is for 2019 (last year for which data from the BERD Survey is available). (**) Direct spending in Northeast Ohio. (***) Total R&D expenditure in Greater Cleveland was estimated by adding the R&D expenditures from companies, academic institutions, public hospitals and clinics, and NASA Glenn Research Center. Private hospitals (Cleveland Clinic and University Hospitals) were excluded to avoid double counting (given that they are included in the figure for companies). **Sources:** Business Enterprise Research and Development (BERD) Survey, Higher Education Research and Development (HERD) Survey, Cleveland Clinic Annual Report 2021, University Hospitals Annual Report 2021, 2021 VA Northeast Ohio Healthcare System Annual Report, Metrohealth System Annual Report 2021, and NASA John H. Glenn Research Center Economic Impact Study FY 2021.





Mapping Greater Cleveland's R&D Ecosystem



Type of institution	N° of locations
Companies	31
NASA Glenn's Research Center	2
Academic institutions	5
Hospitals and clinics	4

Note: Dots represent the location of institutions and companies' R&D facilities. In those cases where we didn't find specific information on the location of the R&D facility, we assumed that the R&D center is located at the institution or company's main operating location in the region.

Greater Cleveland's R&D Ecosystem in Numbers

Type of institution	R&D expenditure (2021)	Largest players in the region	2017-2019 Growth			2019-2021 Growth			Lead Focus	Main source of funding
			Greater Cleveland	Ohio	U.S.	Greater Cleveland	Ohio	U.S.		
Companies	\$2,530 M*		19%	9%	23%	-	-	24%	Automotive mfg. Machinery mfg. Chemical mfg.	Paid by the company
Academic Institutions	\$575 M		3%	9%	11%	-6%	12%	7%	Life sciences Engineering	Federal government
NASA John H. Glenn Research Center	\$557 M**		-	-	-	3%***	7%***	-	Physical sciences Fission surface power Electric aircraft propulsion Communication services (satellites)	Federal government
Hospitals and Clinics	\$505 M		8%	-	-	-11%	-	-	Cardiology & Heart Surgery Cancer	Grants

Notes: (*) Data is for 2019 (last year for which data is available). (**) NEO total direct spending, which includes eight counties: Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage and Summit Counties. (***) The 2020-2021 variation is presented because 2019 data is not comparable.

Sources: Business Enterprise Research and Development (BERD) Survey, Higher Education Research and Development (HERD) Survey, Cleveland Clinic Annual Report, University Hospitals Annual Report, VA Northeast Ohio Healthcare System Annual Report, Metrohealth System Annual Report and NASA John H. Glenn Research Center Economic Impact Studies.

Deep dive into the R&D

Ecosystem

This section describes R&D expenditure, focus, sources of funding, activities and patterns in companies, academic institutions, hospitals and clinics, and NASA Glenn Research Center.

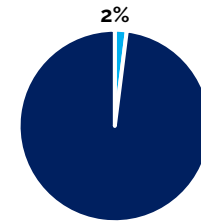


R&D expenditure by companies in Greater Cleveland accounts for 1.3% of the regional GDP; this figure is 1.5% for Ohio and 2.3% for the United States

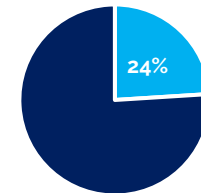
Domestic R&D expenditure by companies* and GDP** in selected geographies. In millions and as percentages, 2019.

Geographic Area	R&D expenditure (\$ M)	Gross Domestic Product (GDP, \$ M)	R&D expenditure as share of GDP
U.S	\$ 492,956	\$ 21,380,976	2.3 %
Ohio	\$ 10,642	\$ 697,167	1.5 %
Greater Cleveland	\$ 2,530	\$ 195,738	1.3 %

Composition of domestic R&D expenditure by companies in selected geographies. 2019.



Ohio vs
the rest of the U.S.
(total: U.S.)



Greater Cleveland
vs the rest of Ohio
(total: Ohio)

Notes: (*) These figures only include domestic R&D expenditure by companies. For multi-establishment firms, this figure only includes data assigned to a specific location by the firm. For single-establishment companies, data reported were allocated to the location in the address used to mail the survey form. (**) GDP for Greater Cleveland was calculated by adding up the GDP of Cleveland-Elyria MSA, Akron MSA, and Canton-Massillon MSA.

Source: Business Enterprise Research and Development (BERD) Survey from the National Science Foundation (NSF).

Companies in Greater Cleveland present a lower R&D intensity ratio than companies in Ohio and in the United States

Domestic R&D expenditure by companies, number of firms, and R&D intensity ratio in selected geographies. 2019.

Geographic Area	R&D expenditure (\$ M)	Firms	Firms in innovative sectors*	R&D intensity ratio**
U.S	\$ 492,956	6,102,412	1,152,280	0.43
Ohio	\$ 10,642	183,281	35,175	0.30
Greater Cleveland	\$ 2,530	59,473	12,310	0.21

Notes: (*) According to the BERD Survey, the sectors with highest domestic R&D expenditure in the U.S. are Manufacturing, Information, and Professional Services. (**) Calculated as the ratio between domestic R&D expenditure in millions in a selected geography and the number of firms in innovative sectors in that same geography.

Source: Business Enterprise Research and Development (BERD) Survey of the National Science Foundation (NSF) and Statistics of U.S. Businesses (SUSB).

R&D expenditure by firms in Greater Cleveland grew 25% between 2016 and 2019; though the region performed better than Ohio, its growth was slower than in the U.S.








Domestic R&D expenditure by companies in selected geographies*. In millions, 2016-2019.

Geographic Area	2016	2017	2018	2019	2016-2019 var (%)
U.S	\$ 374,685	\$ 400,100	\$ 441,036	\$ 492,956	32%
Ohio	\$ 8,892	\$ 9,769	\$ 9,646	\$ 10,642	20%
Greater Cleveland	\$ 2,023	\$ 2,127	\$ 2,325	\$ 2,530	25%

Greater Cleveland is home to innovative companies that globally invest \$ 5.9+ billion on R&D activities

Global R&D expenditure from selected Greater Cleveland's companies* by sector.

In millions and as percentage of the companies' sales revenues, 2021.













Sector	Global R&D expenditure (\$ M)**	Global R&D exp./ sales revenue (%)***	N° of patents granted
 Food Mfg.	\$1,923	1.9%	125
 Automotive Parts Mfg.	\$1,586	2.5%	360
 Machinery Mfg.	\$1,154	3.6%	575
 Chemical Mfg.	\$861	0.8%	251
 Paper Mfg.	\$138	1.6%	90
 Others (Mfg.)****	\$116	1.2%	15
 Others*****	\$143	0.6%	18

Notes: (*) Global R&D expenditure from 24 companies in Greater Cleveland for which data was publicly available. This selection was drawn from an initial list of 40 innovative companies in the region. (**) This figure includes global R&D expenditure from firms located in Greater Cleveland, and thus these numbers will differ from the numbers presented in the previous slides (those slides presented domestic R&D expenditure). (***) The ratio was calculated as the division between global R&D expenditure and the company's sales revenue (also called sales or net sales). (****) Includes miscellaneous manufacturing, electrical equipment, appliance, component manufacturing, and fabricated metal products manufacturing. (***** Includes professional services and mining. **Source:** USPTO and U.S. Security and Exchange Commission (SEC) Form 10-k and annual reports. For companies with headquarters in the U.S., their annual reports tend to have the same structure that Form 10-k submitted to the SEC.









Greater Cleveland has several international companies with branches and facilities in the region that conduct R&D activities (part I)

Global R&D expenditure by companies in Greater Cleveland*. [Non-comprehensive list]

In millions and as percentage of the companies' sales revenues, 2021.

#	Company Name	Main Sector	Global R&D expenditure (\$ M)**	Global R&D exp./ sales revenue (%)***	N° of patents granted****
1	 Nestle	Food manufacturing	\$ 1,865	2.0%	125
2	 BRIDGESTONE	Automotive parts manufacturing	\$ 831	2.9%	211
3	 EATON	Machinery Manufacturing	\$ 616	3.1%	361
4	 GOODYEAR	Automotive parts manufacturing	\$ 496	2.8%	<u>82</u>
5	 PPG	Chemical Manufacturing	\$ 463	2.8%	<u>52</u>
6	 RA Rockwell Automation	Machinery Manufacturing	\$ 423	6.0%	<u>134</u>
7	 Parker	Automotive parts manufacturing	\$ 259	1.8%	<u>67</u>
8	 AVERY DENNISON	Paper manufacturing	\$ 137	1.6%	<u>81</u>
9	 dn Dun & Bradstreet	Professional services	\$ 126	3.2%	<u>12</u>
10	 Dow Chemicals	Chemical Manufacturing	\$ 116	0.6%	<u>20</u>
11	 AVIENT	Chemical Manufacturing	\$ 83	1.7%	4
12	 RPM	Chemical Manufacturing	\$ 78	1.3%	-

Sector













-  Automotive Parts Mfg.
-  Machinery Mfg.
-  Chemical Mfg.
-  Food Mfg.
-  Paper Mfg.
-  Others Mfg.
-  Others
-  Related to healthcare

Notes: (*) R&D expenditure from 24 companies in Greater Cleveland for which data was publicly available. This selection was drawn from an initial list of 40 innovative companies. (**) This figure includes global R&D expenditure from firms located in Greater Cleveland, and thus these numbers will differ from the numbers presented in the previous slides (those slides presented domestic R&D expenditure). (***) The ratio was calculated as the division between R&D expenditure and the company's sales revenue (also called sales or net sales). (****) Estimates. Underlined numbers indicate that the company's patent activity was mainly driven by its headquarter or subsidiary in Greater Cleveland. Numbers in gray indicate that it was necessary to add the patents of different subsidiaries within and outside Greater Cleveland. **Source:** USPTO and U.S. Security and Exchange Commission (SEC) Form 10-k and annual reports.









Greater Cleveland has several international companies with branches and facilities in the region that conduct R&D activities (part II)

Global R&D expenditure by companies in Greater Cleveland*. [Non-comprehensive list]

In millions and as percentage of the companies' sales revenues, 2021.

#	Company Name	Main Sector	Global R&D expenditure (\$ M)**	Global R&D exp./ sales revenue (%)***	N° of patents granted****
13	 STERIS	Miscellaneous Manufacturing	\$ 66	2.1%	4
14	 Nordson	Machinery Manufacturing	\$ 59	2.5%	<u>37</u>
15	 THE J.M. SMUCKER CO.	Food Manufacturing	\$ 58	0.7%	0
16	 LINCOLN ELECTRIC	Machinery Manufacturing	\$ 56	1.7%	43
17	 SAINT-GOBAIN	Chemical Manufacturing	\$ 50	0.1%	<u>168</u>
18	 TIMKEN	Fabricated Metal Product Manufacturing	\$ 37	0.9%	<u>4</u>
19	 synthomer	Chemical Manufacturing	\$ 39	1.2%	1
20	 FERRO	Chemical Manufacturing	\$ 33	2.9%	<u>6</u>
21	 CLIFFS	Mining	\$ 17	0.1%	6
22	 INVIVOCARE Yes, you can!	Miscellaneous Manufacturing	\$ 9	1.0%	<u>7</u>
23	 GRAFTech International	Electrical Equipment Manufacturing	\$ 4	0.3%	0
24	 Ranpak	Paper Manufacturing	\$ 2	0.4%	<u>9</u>

Sector

-  Automotive Parts Mfg.
-  Machinery Mfg.
-  Chemical Mfg.
-  Food Mfg.
-  Paper Mfg.
-  Others Mfg.
-  Others
-  Related to healthcare

Notes: (*) R&D expenditure from 24 companies in Greater Cleveland for which data was publicly available (J.M. Smucker is located in Wayne County, outside the definition of Greater Cleveland used for this report). (**) This figure includes global R&D expenditure from firms located in Greater Cleveland, and thus these numbers will differ from the numbers presented in the previous slides that presented domestic R&D expenditure. (***) The ratio was calculated as the division between R&D expenditure and the company's sales revenue (also called sales or net sales). (****) Estimates. Underlined numbers indicate that the company's patent activity was mainly driven by its headquarter or subsidiary in Greater Cleveland. Numbers in gray indicate that it was necessary to add the patents of different subsidiaries within and outside Greater Cleveland. **Source:** USPTO and U.S. Security and Exchange Commission (SEC) Form 10-k and annual reports.

Lincoln Electric operates the industry's most comprehensive R&D program, supported by its R&D centers around the world, including the advanced **David C. Lincoln Technology Center** in Cleveland, the only facility that combines **research and production in a single location**.

In 2019, **PPG** opened a new research lab at Cleveland Coatings Plant focused on electric, driverless vehicles. The lab was previously based at a PPG facility in Adrian, Michigan. PPG moved the facility to take advantage of the Cleveland area's technically trained workforce. The West Park complex is **PPG's largest automotive manufacturing and technical center** in the Americas.

Avient has 11 global innovation centers, 4 in the U.S., and one of those located in Avon Lake, OH. Avient is formulating specialty polymer solutions with their Phased Offering Launch process, a proprietary means through which they take new solution ideas from concept to commercialization.

Swagelok is an industry leader in fluid systems for many industrial applications. They have technical expertise on the semiconductor, clean energy, and oil, gas and refining markets. They also have deep expertise in material science, surface treatment, and machining of corrosion resistant metals.

Sherwin-Williams breaks ground on new 600,000-square-foot **Global R&D Center** in Brecksville, Cuyahoga County. The construction started in October 2021, and it is **expected to open by the end of 2024**. The new R&D Center will support product development, coatings research, color technology and process engineering. The facility will house approximately 900 employees, with room to accommodate future growth.

As part of their R&D program, **RPM International** is creating resilient coatings for wind turbine blades to reformulating products with bio-based materials. It also provides formal and informal incentives to associates for creating, implementing and using more sustainable products and processes. They promote the sharing of best practices and innovative ideas among the company through the **Connections Creating Value program**.

The Goodyear Tire & Rubber Company's R&D center in Akron, Ohio opened in 1978 and serves the North American and Latin American markets. The Goodyear Innovation Center at Akron is the **main R&D Center of the company**.

Bridgestone's Technology center in Akron is the **only one in the U.S.**

The Timken Company's largest technical center is located at the Company's world headquarters in North Canton. In 2013, a partnership with Stark State College led to development of a new **Technology and Test Center**, the first of its kind in the Americas. The test center also houses a classroom and lab for training students in electrical and mechanical engineering.

Avery Dennison's headquarters are in Mentor, Ohio. Its **Mentor Innovation Center** has several specialty labs with technological and scientific resources, focusing on development of roll-to-roll coating and materials science. Some of the main capabilities are outdoor and indoor weathering simulation stations, and a UL accredited lab.

GE Lighting, a Savant Company development Efforts are focused on the smart home and connected devices, while they maintain skills and expertise in mechanical and electrical engineering, including the development of connected light bulbs and switches, among others.

In November 2022, Canon announced it will invest \$300M to launch a U.S.-based medical imaging company (**Canon Healthcare USA**) and double its R&D efforts in the U.S.

After about 30 years at its former headquarters in Eaton Center, **Eaton Corporation** sought to unify its Cleveland-area employees and moved its headquarters to a 580,000 sqft facility in suburban Beachwood. This facility houses ~700 Eaton employees that were previously located at the Eaton Center in downtown Cleveland, a telecomputer center in Eastlake, and a learning and technology center in Willoughby Hills.

Nestlé is the food group with the **world's biggest R&D network**. The firm opened a new R&D center in Solon (Ohio) in 2015, designated to serve as global **Product Technology Center**. It is **Nestlé's second business unit in Ohio** and its **12th global center of excellence** dedicated to product and process development. They also have proprietary technology for production of plant-based meat analogs.

In 2017, **Parker Hannifin** opened a new state-of-the-art **Advanced Manufacturing Learning and Development Center** located at Parker Technology Center facility in Macedonia, OH. This facility serves as a center of excellence where Parker engineers can explore new applications of emerging technologies such as additive manufacturing and collaborative robotics.

Synthomer (OMNOVA Solutions) has a **Global Technology Center** in Akron, where their efforts are focused on developing new applications with their base technologies, enhancing the functionality of their products in existing applications, as well as developing new product and technology platforms.

Diebold Nixdorf conducts R&D to reduce waste, prevent pollution, increase the use of sustainable materials and conserving resources. In 2021, Diebold Nixdorf's Sustainability, R&D, Systems, and Procurement departments initiated a long-term project to perform product life cycle assessments, which will help to build sustainability into their products and systems at the early development stage.

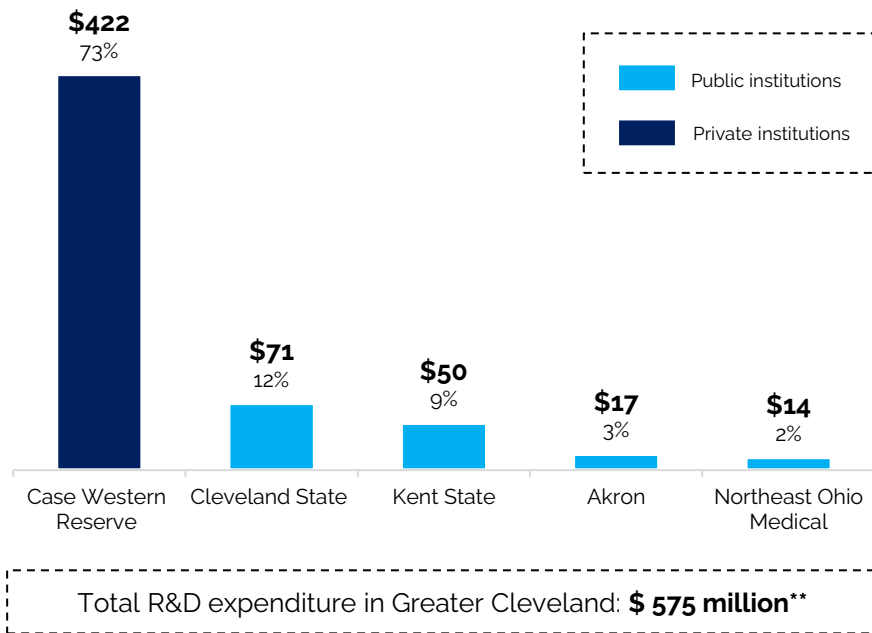
Type of institution

- Companies
- NASA Glenn's Research Center
- Academic institutions
- Hospitals and clinics

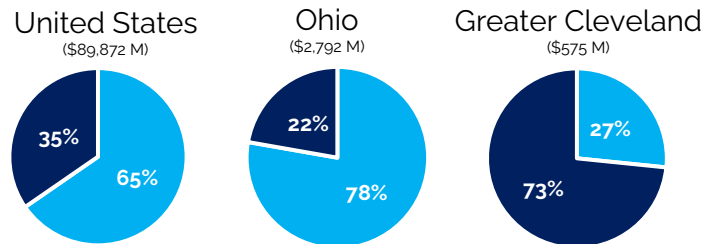
Note: Dots represent the location of companies' R&D facilities. In those cases where we didn't find specific information on the location of the R&D facility, we assumed that the R&D center is located at the company's main operating location in the region.

Academic institutions in Greater Cleveland invested \$575 M on their R&D efforts during 2021; 73% of those investments came from Case Western Reserve University

R&D expenditure by academic institution in Greater Cleveland. In millions and as percentage of total, 2021.



R&D expenditure by type of academic institution in selected geographies. 2021.



NASA Glenn's educational awards in Greater Cleveland by academic institution*. In millions, 2021.

Academic institution	Award amount (\$M)	% of total awards in Ohio
CWRU	\$ 2.41	38.0%
Akron	\$ 0.56	8.8%
Kent State	\$ 0.04	0.6%
Cleveland State	\$0.03	0.5%

In FY 2021, NASA Glenn awarded **\$13.6 million** to colleges and universities in 31 states. Academic institutions in **Ohio received \$6.3 million**, which accounted for the largest share (47%) of NASA Glenn's academic awards for the year. Of all Ohio academic institutions, the **University of Toledo (42.2%) and CWRU (38.0%) were awarded the most in FY 2021**. The two universities combined accounted for 80.2% of Ohio's total awards.

Notes: (*) Other Ohio academic institutions receiving NASA Glenn's awards in FY 2021 were Toledo (42.2%), Ohio State (8.3%), Ohio (1.5%), and Cincinnati (0.1%). (**) Due to rounding, the total may not correspond to the sum of all figures shown. **Source:** NASA Glenn Research Center Reports FY 2021.

Contrary to R&D expenditure trends across the United States and in Ohio, between 2019 and 2021 R&D expenditures by academic institutions in Greater Cleveland decreased

R&D expenditure by academic institution in selected geographies*.

In millions, 2017-2021.

Geography	2017	2018	2019	2020	2021	2017-2019 var (%)	2019-2021 var (%)
U.S.	\$ 75,315	\$ 79,436	\$ 83,653	\$ 86,435	\$ 89,872	11%	7%
Ohio	\$ 2,302	\$ 2,372	\$ 2,502	\$ 2,522	\$ 2,792	9%	12%
Greater Cleveland**	\$ 595	\$ 611	\$ 614	\$ 608	\$ 575	3%	-6%





















Notes: (*) Last update: 03/24/2021 (**) Includes R&D expenditure from Case Western Reserve, Cleveland State, Kent State, Akron, and Northeast Ohio Medical.




Source: Higher Education Research and Development (HERD) Survey.

75% of R&D expenditure by academic institutions in Greater Cleveland goes to the Life Sciences field; this figure is larger than in Ohio and the United States

Field of R&D expenditure by academic institution in Greater Cleveland.






In millions and as percentage of total, 2021.

R&D field	Greater Cleveland		Specialization ratio*			
	\$ M	% of total	Vs. Ohio		vs. US	
Life sciences	\$ 430	75%		1.1		1.3
Engineering	\$ 63	11%		0.6		0.7
Physical sciences	\$ 26	4%		1.1		0.7
All non-S&E fields*	\$ 22	4%		0.9		0.7
Social sciences	\$ 17	3%		1.6		0.9
Psychology	\$ 7	1%		1.4		0.8
Computer and information sciences	\$ 4	1%		0.5		0.2
Mathematics & statistics	\$ 3	1%		1.3		0.6
Geosciences, atmospheric, and ocean sciences	\$ 2	0%		0.4		0.1
Sciences (not elsewhere classified)	\$ 1	0%		0.1		0.2
Total	\$ 575	100%				

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Largest R&D field by academic institution.













In millions and as percentage of total, 2021.




Institution	R&D field	R&D exp. (\$ M)	% of total
 Case Western Reserve	Life sciences	\$ 360	85%
 Cleveland State	Life sciences	\$ 45	63%
 Kent State	All non-S&E fields**	\$ 14	29%
 Akron	Engineering	\$ 8	44%
 Northeast Ohio Medical	Life sciences	\$ 14	100%

Notes: (*) Calculated as the ratio between the share of R&D expenditure in a certain field in Greater Cleveland and the share of R&D expenditure in that same field in Ohio and in the U.S. (**) S&E: Science and engineering. **Source:** Higher Education Research and Development (HERD) Survey.






74% of R&D expenditure made by academic institutions in Greater Cleveland is financed by the federal government; this figure is larger than in Ohio and the U.S.

Source of funds for R&D expenditure by academic institution in Greater Cleveland. In millions and as percentage of total, 2021.

R&D source of funds	Greater Cleveland		Specialization ratio*	
	\$ M	% of total	vs Ohio	vs. US
Federal government	\$ 422	73%	 1.3	 1.3
Institutions	\$ 106	18%	 0.7	 0.7
Nonprofit organizations	\$ 27	5%	 1.1	 0.8
Businesses	\$ 8	1%	 0.2	 0.3
State and local government	\$ 8	1%	 0.5	 0.3
All other sources	\$ 4	1%	 0.4	 0.2
Total	\$ 575	100%		

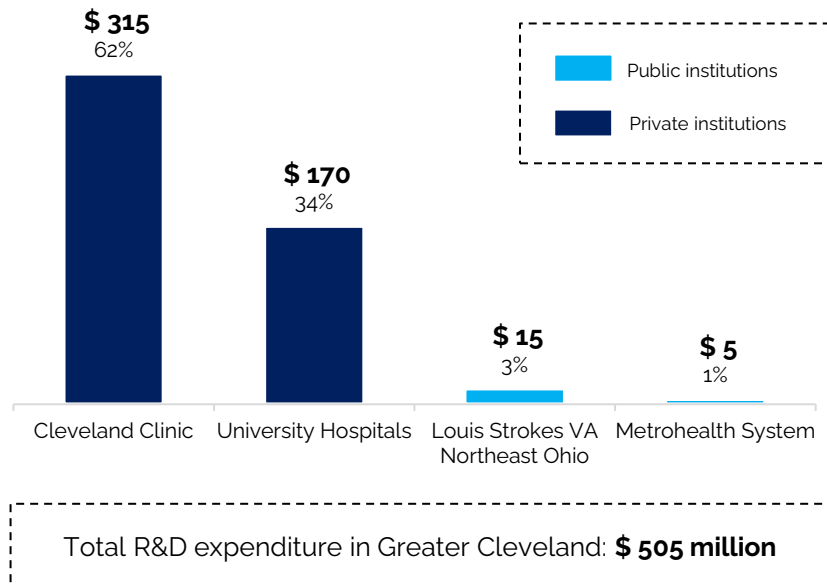
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Largest R&D source of funds by academic institution. In millions and as percentage of total, 2021.

Institution	R&D source of funds	R&D (\$ M)	% of total
 Case Western Reserve University	Federal government	\$ 340	81%
 Cleveland State University	Federal government	\$ 47	66%
 Kent State University	Institutions	\$ 31	62%
 The University of Akron	Federal government	\$ 9	52%
 Northeast Ohio Medical University	Federal government	\$ 10	72%

Hospitals and clinics in Greater Cleveland invested \$505 M on R&D activities in 2021; sources of funds for these activities vary considerably by institution

R&D expenditure by hospitals and clinics in Greater Cleveland. In millions and as percentage of total, 2021.



R&D profile of hospitals and clinics in Greater Cleveland*. 2021.

Institution	R&D exp./ OpRev.**	Source of funds		Main Research Focus*
		Source	%*	
Cleveland Clinic	2.9%	Industry	41%	• Cardiology & Heart Surgery
		Federal	37%	• Neurology
		Internal	22%	• Ophthalmology
University Hospitals	3.2%	Federal***	58%	• Pathogen
		Industry****	42%	• Cancer
VA U.S. Department of Veterans Affairs	1.1%			• Rehabilitation
				• Infections Diseases
				• Cardiology
MetroHealth	0.3%	Internal	71%	• Diabetes
		Federal*****	29%	• Cancer

Notes: (*) Estimates based on annual institutional reports. Sources of funds were recategorized for standardizing the analysis. (**) While Metrohealth System and UH report operating revenue, Cleveland Clinic reports operating income before accounting for interest, depreciation, and amortization, and Luis Stokes VA Northeast Ohio only discloses its operating budget. Thus, ratios reported in the table are not directly comparable. (***) Joint UH-CWRU clinical and translational research. Includes NIH grants to CWRU School of Medicine attributable to UH Cleveland Medical Center. (****) Sponsored research funding. Includes industry-sponsored clinical trials. (*****) CICIP: Care Innovation and Community Improvement Program (CICIP) backed by the Department of Medicaid of Ohio. The percentages for each of the sources of funds for Metro Health are an estimate based on sources of funds for the category 'Community benefits'. **Source:** Cleveland Clinic Annual Report 2021, University Hospitals Annual Report 2021, 2021 VA Northeast Ohio Healthcare System Annual Report and Metrohealth System Annual Report 2021.

Between 2020 and 2021, total R&D expenditure by hospitals and clinics in Greater Cleveland remained stable; yet spending decreased at UH and VA NEO Healthcare

R&D expenditure by selected hospitals and clinics in Greater Cleveland.

In millions, 2017-2021.

Institution	2017	2018	2019	2020	2021	2020-2021 var (%)
Greater Cleveland	\$ 523	\$ 535	\$ 567	\$ 502	\$ 505	1%
Cleveland Clinic Foundation	\$ 267	\$ 286	\$ 298	\$ 304	\$ 315	4%
University Hospitals*	\$ 256	\$ 249	\$ 266	\$ 177*	\$ 170	-4%
VA Northeast Ohio Healthcare System				\$16	\$15	-7%
Metrohealth System	-	-	\$ 3	\$ 4	\$ 5	21%

Notes: (*) In 2020, University Hospitals stopped receiving funds for the joint UH-CWRU School of Medicine basic science research, which accounted for \$105 M in 2019.

Sources: [Cleveland Clinic Annual Reports](#), [University Hospitals Annual Reports](#), [Metrohealth System Annual Reports](#), [VA Northeast Ohio Healthcare System Annual Reports](#).

In 2021, NASA Glenn spent \$557 M in Greater Cleveland, showing a 3% increase compared to 2020

NASA Glenn's direct spending in selected geographies.

In millions, 2020-2021.

Geography	2020	2021	2020-2021 var (%)
Ohio*	\$558	\$596	7%
Northeast Ohio**	\$ 541	\$ 557	3%

- >> **NASA John H. Glenn Research Center** performs research, engineering development, and testing to advance aviation, enabling exploration of the universe, and improving life on Earth.
- >> The **Center's core capabilities** concentrate on biological & physical sciences, fission surface power research, electric aircraft propulsion, and communication services (satellites).
- >> NASA Glenn is leading the **Advanced Air Transport Technology Project**. The research involves making giant strides in energy efficiency and environmental compatibility.

Notes: (*) NASA Glenn's direct spending in Ohio. These expenditures include purchases in Ohio in FY 2021 and expenditures on labor income paid to employees living in Ohio. (**) NASA Glenn's direct spending in Northeast Ohio (NEO). For FY 2021, these expenditures include a total amount of \$312 M spent on purchases in NEO and expenditures on labor income paid to employees living in NEO for \$245 M. NEO includes eight counties: Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage and Summit Counties. **Source:** NASA Glenn Research Center Reports FY 2020 and 2021.

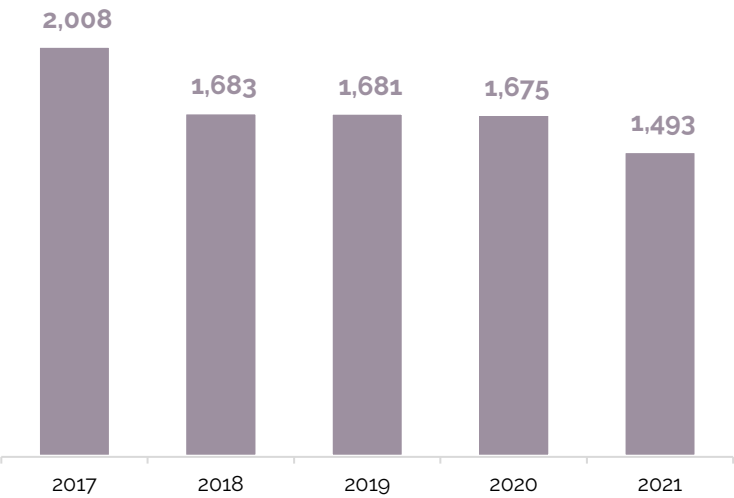
Patenting Activity

This section explores the evolution of patents granted in the region and the organizations leading patenting activity.



Between 2017 and 2021, more than 8,500 patents were granted to Greater Cleveland's companies; Rockwell and Goodyear Tire & Rubber led the patenting activity

Patents granted to assignees in Greater Cleveland*. 2017-2021.



Patents granted in Greater Cleveland 2017-2021: **8,540**

Top 10 assignees** in Greater Cleveland* by total number of patents granted. 2017-2021.

#	Organization Name	Type of organization	N° of Patents***
1	 Rockwell Automation Technologies, Inc.	Companies	758
2	 Goodyear Tire & Rubber Company	Companies	650
3	 Eaton Corporation	Companies	469
4	 Case Western Reserve University	Academic institutions	464
5	 Parker-Hannifin Corporation	Companies	301
6	 Cleveland Clinic Foundation	Hospitals & Clinics	293
7	 PPG Industries Ohio, Inc.	Companies	277
8	 Avery Dennison Retail Information Services, LLC	Companies	233
9	 GOJO Industries, Inc.	Companies	212
10	 Akron University	Academic institutions	203

Notes: (*) The total number of patents granted per year was obtained by adding patents granted to headquarters or subsidiaries located in the cities in Greater Cleveland that are part of the top 200 global locations by patent count since 2013, according to USPTO. These cities are Cleveland, Akron, Solon, Mayfield Heights, and Mentor. (**) During examination of a pending patent application or after the patent is granted, the owner of the patent may transfer ownership to another entity or party, through an "assignment". The receiving party (i.e., the assignee) is typically a company, university, research lab, or other entity that employs the inventor(s). It is possible that the inventor and the assignee are the same. The assignment of a patent is independent of inventorship. (***) The list of top organizations ranks patents granted to a headquarter or subsidiary (assignee) located in any of the five cities mentioned above. For this reason, when the assignee (subsidiary or headquarter) of a patent granted is located outside the region or the U.S. (such as Nestlé and Bridgestone), it does not appear on the list. **Source:** [U.S. Patent and Trademark Office \(USPTO\); Patents View \(USPTO\)](#).

Business and Capital Landscape

This section presents a snapshot of Greater Cleveland's business landscape and its specialization. It also analyses the evolution of capital investments and innovation awards in the region, as well as their main recipients.



Greater Cleveland is specialized in Manufacturing, Management of Companies Wholesale Trade and Healthcare

Employment and LQs* in Greater Cleveland by industry. 2-digit NAICS, 2019

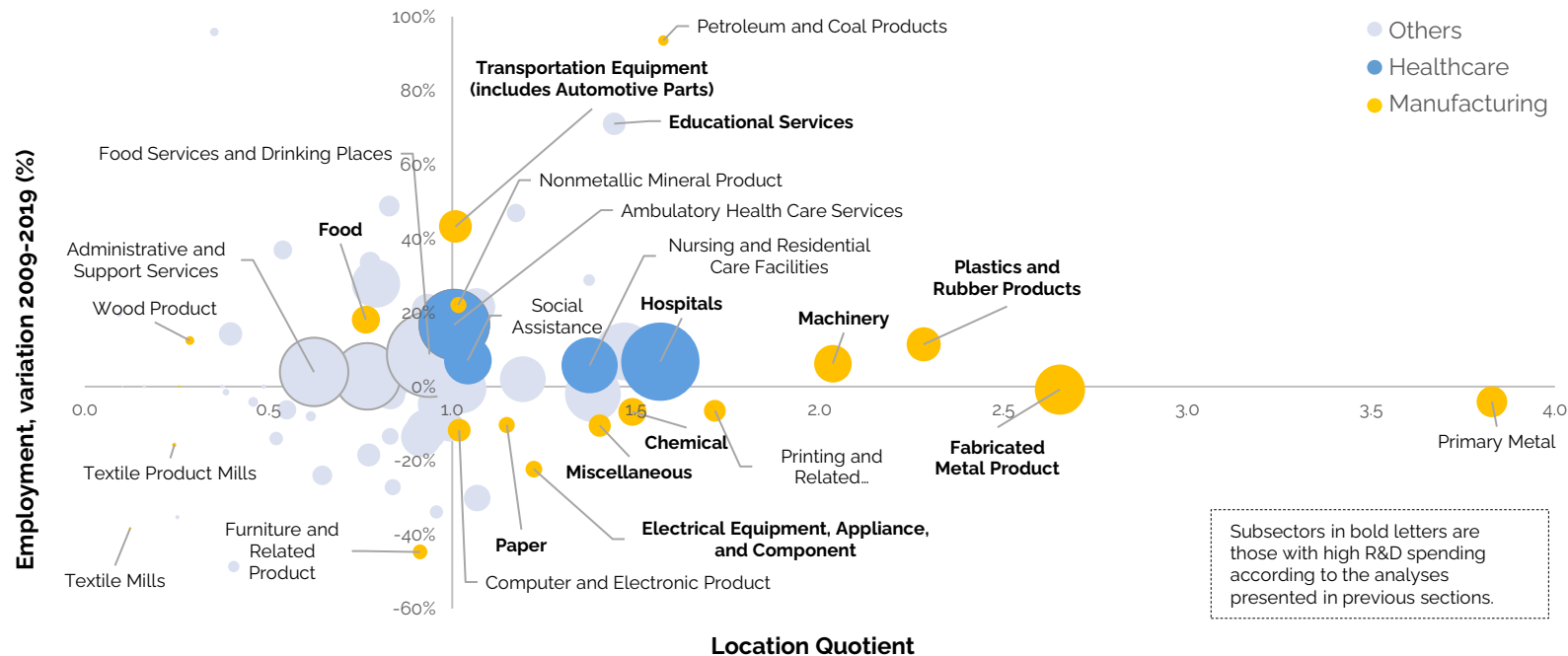
NAICS Code	NAICS Description	Employment	LQs	Firms**					
				< 20 employees		20-99 employees		100+ employees	
				N*	%	N*	%	N*	%
-	Total	1,376,204	-	47,512	78%	6,754	11%	6,274	10%
62	Health Care and Social Assistance	266,893	1.2	4,430	75%	832	14%	625	11%
31-33	Manufacturing	185,621	1.5	2,558	61%	963	23%	675	16%
44-45	Retail Trade	157,155	1.0	4,676	78%	443	7%	906	15%
72	Accommodation and Food Services	128,458	0.9	3,751	70%	1,155	22%	415	8%
56	Administrative and Support and Waste Management Services	84,040	0.6	3,204	81%	349	9%	392	10%
42	Wholesale Trade	76,901	1.2	2,849	69%	574	14%	733	18%
54	Professional, Scientific, and Technical Services	73,810	0.8	6,449	87%	483	7%	483	7%
52	Finance and Insurance	68,320	1.0	2,224	79%	163	6%	439	16%
81	Other Services (except Public Administration)	58,802	1.0	6,354	89%	513	7%	237	3%
23	Construction	55,200	0.8	5,261	90%	467	8%	150	3%
55	Management of Companies and Enterprises	50,366	1.4	68	15%	56	12%	342	73%
48-49	Transportation and Warehousing	40,570	0.7	1,376	74%	181	10%	300	16%
61	Educational Services	40,337	1.0	601	66%	227	25%	84	9%
51	Information	35,664	1.0	453	65%	69	10%	177	25%
71	Arts, Entertainment, and Recreation	25,055	1.0	862	81%	142	13%	63	6%
53	Real Estate and Rental and Leasing	20,626	0.9	2,204	87%	127	5%	214	8%
22	Utilities	6,750	1.0	14	35%	4	10%	22	55%
21	Mining, Quarrying, and Oil and Gas Extraction	1,319	0.2	56	71%	6	8%	17	22%
11	Agriculture, Forestry, Fishing and Hunting	243	0.1	55	100%	-	0%	-	0%
99	Industries not classified	74	0.5	67	100%	-	0%	-	0%

LQ>1

Notes: (*) LQs by industry are calculated as the ratio between the region's industry employment divided by the region's total employment and the U.S. industry employment divided by the U.S. total employment. (**) Due to rounding, the total may not correspond with the sum of the separate figures. **Source:** [Statistics of U.S. Businesses \(SUBS\)](#)

Greater Cleveland is highly specialized in the same subsectors that are driving R&D spending — especially those related to manufacturing

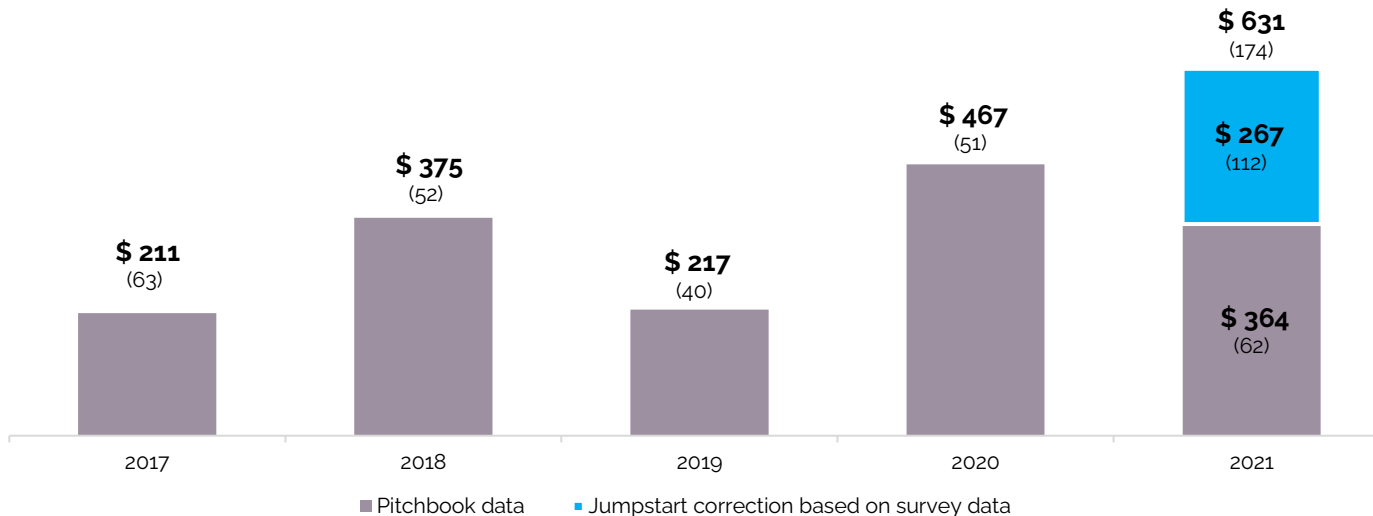
Location Quotient (2019) and employment change (2009-2019) in Greater Cleveland*.
3-digit NAICS. Bubble size represents employment in Greater Cleveland.



Note: (*) the vertical axis was constrained for presentation purposes. Thus, a few categories (Apparel Manufacturing, Lessors of Nonfinancial Intangible Assets, Beverage and Tobacco Products Manufacturing and Publishing Industries) were excluded from the chart. **Source:** own elaboration based on [County Business Patterns](#).

Between 2017 and 2021, 350+ companies in Greater Cleveland raised \$1,900 million in capital

Capital investments and number of companies involved in deals in Greater Cleveland*. In millions, 2017-2021.



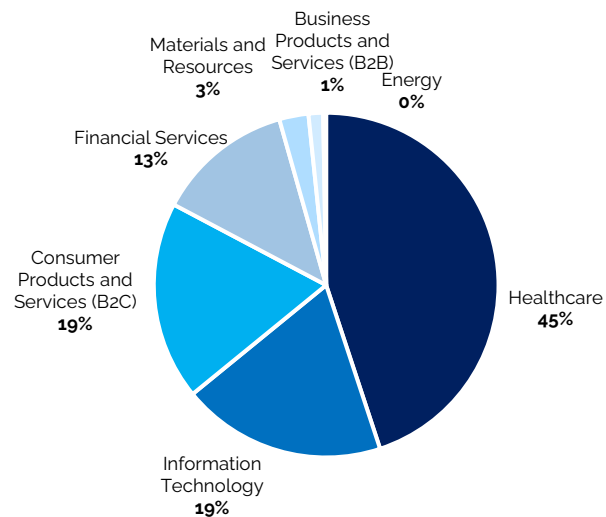
Capital investments in Greater Cleveland 2017-2021: ~\$ 1,900 million**

Notes: (*) The database includes some companies with headquarters located in cities that do not fit the definition of Greater Cleveland for the report (Cleveland-Elyria MSA, Akron MSA and Canton-Massillon MSA). It also includes 4 transactions in 2021 with deal status "Failed/Cancelled", and 3 "Announced/In Progress". (**) Estimate. Some deals in the database did not provide information regarding the deal size and were excluded from this analysis. Approximately 80% of the deals listed in the database had information about the deal size. The total includes the correction to 2021 data made by JumpStart, where through a survey they incorporated companies and deals that were absent in the Pitchbook database.

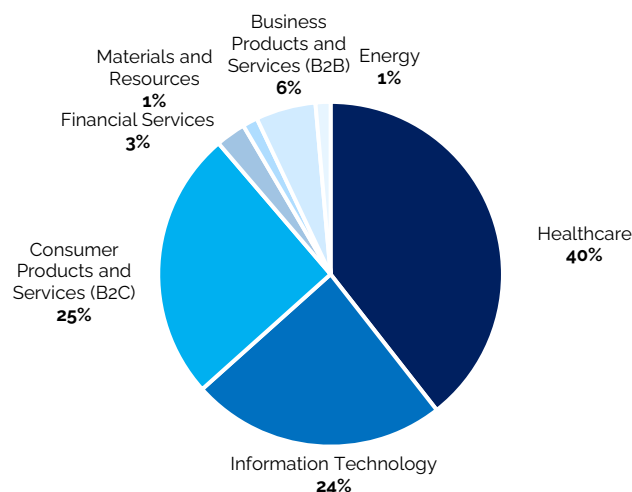
Source: PitchBook and JumpStart based on PitchBook data and survey data.

The healthcare sector accounted for ~45% of total capital raised by companies located in Greater Cleveland during 2021

Capital investments* in Greater Cleveland.
By primary industry sector, as percentage of capital raised, 2021.



Capital investments* in Greater Cleveland.
By primary industry sector, as percentage of deals closed**, 2021.



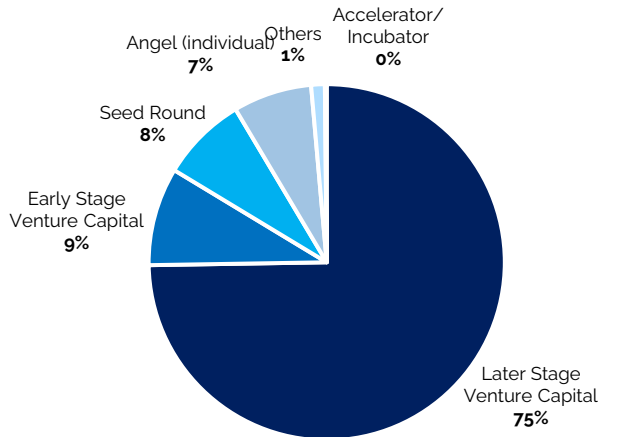
Industry sector	Average deal size (\$M)
Financial Services	\$ 23.6
Materials and Resources	\$ 10.0
Healthcare	\$ 5.8
Information Technology	\$ 4.1
Consumer Products and Services (B2C)	\$ 3.8
Business Products and Services (B2B)	\$ 1.1
Energy	\$ 0.5

Note: (*) The database includes some companies with their headquarters located in cities that do not fit the definition of Greater Cleveland in this report (Cleveland-Elyria MSA, Akron MSA and Canton-Massillon MSA). It also includes 4 transactions with deal status "Failed/Cancelled", and 3 "Announced/In Progress". Investments received as part of an accelerator program are not included; however, if the accelerator continues to invest in follow-on rounds, those further financings are included. Only Pitchbook data was considered for this analysis. (**) Some deals in the database did not provide information regarding the deal size and were excluded from this analysis. Approximately 80% of the deals listed in the database have information about the deal size. **Source:** PitchBook data.

Later stage venture capital accounted for ~75% of total capital raised by companies located in Greater Cleveland during 2021

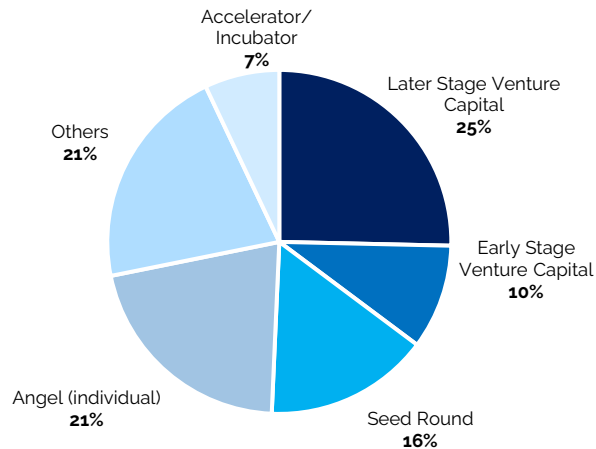
Capital investments* in Greater Cleveland.

By deal type, as percentage of capital raised, 2021.



Capital investments* in Greater Cleveland.

By deal type, as percentage of deals closed, 2021.



Deal type	Average deal size (\$M)
Later Stage VC	\$15.1
Early Stage VC	\$4.6
Seed Round	\$2.6
Angel (individual)	\$1.7
Others	\$0.3
Accelerator/Incubator	\$0.1

Note: (*) The database includes some companies with their headquarters located in cities that do not fit the definition of Greater Cleveland in this report (Cleveland-Elyria MSA, Akron MSA and Canton-Massillon MSA). It also includes 4 transactions with deal status "Failed/Cancelled", and 3 "Announced/In Progress". Investments received as part of an accelerator program are not included; however, if the accelerator continues to invest in follow-on rounds, those further financings are included. Only Pitchbook data was considered for this analysis. (**) Some deals in the database did not provide information regarding the deal size and were excluded from this analysis. Approximately 80% of the deals listed in the database have information about the deal size. **Source:** PitchBook data.

During 2017-2021, top 10 companies raised ~40% of venture capital

Top 10 companies in Greater Cleveland by total capital raised*

In millions, 2017-2021.

Company Name	N° of investors	Total N° of deals	Capital raised	Deal Type	Primary Industry
RVshare	2	3	\$164.3	PE Growth	Consumer Products and Services
BioMotiv	6+	1	\$145.7	Later Stage VC	Healthcare
Neuros Medical	14	4	\$104.9	Later Stage VC	Healthcare
Withing3	2	1	\$100.0	PE Growth	Information Technology
Keyfactor	4	3	\$87.4	Later Stage VC & PE Growth	Information Technology
Splash Financial	13	4	\$64.3	Later Stage VC & Seed Round	Financial Services / Information Technology
Diasome	5	3	\$46.5	Later Stage VC	Healthcare
SPR Therapeutics**	3	1	\$70.0	Later Stage VC	Healthcare
AlgiSys	4	1	\$ 45.0	Later Stage VC	Consumer Products and Services
TearClear	9	3	\$32.0	Early Stage VC	Healthcare

■ Manufacturing
 ■ Healthcare
 ■ Others

Top 5 investors by number of deals supported*. 2017-2021.



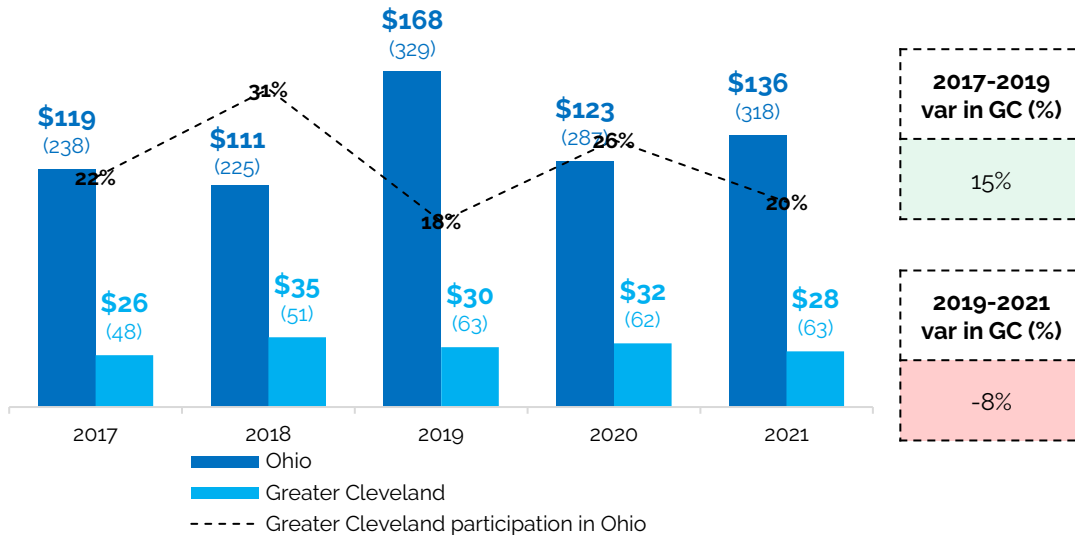
Top investors by capital invested***. 2017-2021.



For **2021**, **JumpStart** identified two deals that do not appear in this table because it only presents PitchBook data. The companies closing those deals were **Alviere (\$62.8 M)** and **Nullable, Inc. (\$58.2 M)**.

Between 2017 and 2021, 110 companies in Greater Cleveland received 287 SBIR/STTR awards, totaling \$ 151 million

SBIR/STTR award amounts and number of awards for companies in Greater Cleveland and Ohio*. In millions, 2017-2021.



Total award amount in Greater Cleveland 2017-2021: **\$ 151 million**

- >> The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) awards are part of the Small Business Program.
- >> **These are highly competitive awards that encourage domestic early-stage small businesses to engage in Federal R&D.**
- >> These awards often provide **initial funding to help small companies turn ideas into commercially viable products.**











Businesses Ownership. In number of companies and as a percentage of total, 2021.

Business Type	Percentage	Count
Woman Owned Businesses	15%	6 out of 39
Socially and Economically Disadvantaged Businesses	13%	5 out of 39
Hubzone Owned Businesses	13%	5 out of 39

Only 3 companies received 1 out of 4 dollars from SBIR/STTR awards in Greater Cleveland: Euclid Techlabs, Euclid Beamlabs, and BGI

Top 10 companies by SBIR/STTR awards*




In millions, 2017-2021.

Company	Total N° of awards	Total award amount (\$M)	Description of largest project
 Euclid Techlabs	30	\$15.1	Development of Advanced MPE CVD System for Growth of Large Diffraction Grade Single-Crystal Diamonds with Low Density of Defects (2021, 1.1 M).
 Euclid Beamlabs	28	\$11.9	Laser-free Ultrafast Tunable Stroboscopic TEM imaging for Biomedical Applications (2020, 1.5 M).
 BGI LLC	4	\$8.4	Tool for automated performance measurement and assessment from embarked carrier landings (2018, 3.3 M).
 SPR Therapeutics	3	\$6.1	Peripheral nerve stimulation for amputee pain (2017, 3.0 M).
 Orbital Research	11	\$5.7	Scalable Control Actuation System and Configurable Guidance Sensor Suite for Multiple Caliber Rounds (2017, 1.5 M).
 Powdermet	16	\$5.3	Load Bearing Thermal Protection Structure for Hypersonic Flight (2018, 1.5 M).
 Terves	11	\$4.1	High Ductility Magnesium Alloy Extrusions for Vehicle Light Weighting (2021, 1.1 M).
 Advanced Imaging Research	3	\$3.9	Compact neonate to adult neuroimaging MRI system (2019, 2.0 M).
 Bioinvision	3	\$3.8	System-independent quantitative cardiacCT perfusion (2021, 2.0 M).
 Centerline Biomedical	4	\$3.8	IOPSxV: Novel Visualization for Non-Fluoroscopic 3D Image Guidance for Peripheral Vascular Interventions (2020, 1.5 M).

SPR Therapeutics ranked 8th in capital investments in Greater Cleveland during 2017-2021, receiving a later stage VC investment for \$37.0 M in 2021.

Terves manufactures engineered response materials for the oil and gas industry. The company also received an angel investment for \$5.0 M in 2017.

Centerline Biomedical also received 2 investments for a total of \$25 M during 2017-2021, ranking 15th in Greater Cleveland in capital raised.

 Manufacturing  Healthcare  Others

Note: (*) The database is continually updated throughout the year and historical data may be subject to revision. Last update of this slide: 03/27/2023.

Source: U.S. Small Business Administration, America's Seed Fund.

Thank you!

April 2023



Methodology Notes | Companies Part 1

- » **Source:** BERD survey. 2019 is the last year data for which data is available.
- » **Population:** A nationally representative sample of for-profit companies in manufacturing and nonmanufacturing industries that have 10 or more paid employees in the U.S., and at least one establishment that is in business during the survey year and is located in the U.S. Companies that performed or funded less than \$50,000 of R&D are excluded from tabulation.
- » **R&D expenditure:** Includes all domestic R&D expenditure from companies (salaries, equipment, supplies, lease and other purchased services) located in the Greater Cleveland region. 83% of domestic R&D expenditure by companies is paid by the company. R&D paid by others is the cost of R&D funded by others outside of the company and performed within the respondent company's facilities. Others could be other companies located inside the U.S., a company's foreign parent, other companies located outside the U.S., U.S. federal government agencies or laboratories, U.S. state and local government agencies or laboratories, foreign government agencies or laboratories, universities, colleges, and academic researchers (including principal investigators) located inside the U.S., universities and colleges located outside the U.S., all other organizations inside the U.S., all other organizations outside the U.S.
- » **Geography:** Includes domestic R&D expenditures in Cleveland-Elyria MSA and Akron MSA. R&D expenditure reported for Canton-Massillon MSA was zero.
- » **Other clarifications I:** For multi-establishment firms, this figure only includes data assigned to a specific location by the firm. For single-establishment companies, data reported were allocated to the location in the address used to mail the survey form.
- » **Other clarifications II:** BERD predecessors were the Survey of Industrial Research and Development (SIRD) (1953-2007), the Business R&D and Innovation Survey (BRDIS) (2008-16), and the Business Research and Development Survey (BRDS) (2017-18). While SIRD and BRDIS collected statistics for businesses with 5 or more employees, BRDS produced (and BERD produces) statistics for businesses with 10 or more employees. Beginning in survey year 2018, companies that performed or funded less than \$50,000 of R&D were excluded from tabulation. These changes have affected the comparability of BERD estimates to those published in prior years, although it is estimated that companies that performed or funded less than \$50,000 of R&D accounted for a very small percentage of total domestic R&D.

Methodology Notes | Companies Part 2

- » Slides 10, 11 and 12 present global R&D expenditure for 24 companies in Greater Cleveland for which data was publicly available. This selection was drawn from an initial list of 40 innovative companies in the region.
- » Certain companies present nuances in the way in which they calculate their global R&D expenditures, limiting comparability in some cases. For instance, PPG Industries and The J.M. Smucker Company mention that depreciation and maintenance expenses associated with research facilities are included in their R&D expenditure figures. Conversely, Diebold Nixdorf Inc incorporates spending on research, development and engineering, while excluding specific software development costs. Ferro Corporation reports comprehensive expenditure figures for product and application technologies, encompassing R&D, customer technical support, and other related activities. Lastly, Ranpak Holdings Corp records R&D costs as incurred within other operating expenses, net.
- » Although most companies have a fiscal period spanning from January 1, 2021 to December 31, 2021, there are some exceptions. Specifically, Rockwell Automation (September 30), Parker-Hannifin (June 30), RPM International (May 31), STERIS Corporation (March 31), and Nordson (October 31).
- » The metric "Global R&D exp./sales revenue (%)" was obtained by dividing global R&D expenditure by the company's sales revenue, which is also called sales or net sales in their reports. Nonetheless, firms such as Bridgestone, Steris Corporation, Synthomer, Cleveland-Cliffs, and Ranpak Holdings report their revenue or net revenue figures instead of sales revenue. In the context of a 10-K report filing with the Securities and Exchange Commission (SEC) in the United States, the terms "revenue" and "sales" are generally used interchangeably, denoting the monetary proceeds generated by a company's core business operations over a specific period. However, it is plausible for a company to generate additional income from sources unrelated to its primary business activities, such as investment gains or asset sales. In such scenarios, these supplementary earnings may be accounted for separately from revenue or sales.
- » This report presents R&D expenditure by companies from two different sources that are not comparable. On the one hand, this report presents total domestic R&D expenditure by companies in Greater Cleveland for 2019 (last data available from BERD Survey). On the other hand, this report presents global R&D expenditure for 24 companies located in Greater Cleveland, based on their reports to the U.S. Securities and Exchange Commission and their published annual reports.

Methodology Notes | Academic Institutions

- » **Source:** HERD survey. 2021 is the last year for which data is available.
- » **Population:** U.S. colleges and universities that expended at least \$150,000 in separately accounted for R&D and were geographically separate campuses headed by a president, chancellor, or equivalent. In Greater Cleveland, these universities are Case Western Reserve U., Cleveland State U., Kent State, Akron U., Northeast Ohio Medical U. and Oberlin College.
- » **R&D expenditure:** Includes R&D expenditure at U.S. colleges and universities located in the Greater Cleveland. R&D expenditures include cost categories such as salaries, software, equipment, and indirect costs.
- » **Geography:** U.S. colleges and universities located in Cleveland-Elyria MSA, Akron MSA or Canton-Massillon MSA. There may be other academic institutions in the area, but only the ones with publicly available data published by the National Science Foundation are included.

Methodology Notes | Hospitals & Clinics

- » **Source:** own elaboration based on [Cleveland Clinic Annual Report 2021](#), [University Hospitals Annual Report 2021](#), [VA Northeast Ohio Healthcare System Annual Report 2021](#), and [Metrohealth System Annual Report 2021](#). Up to February 2023, 2021 is the last year for which these reports were available.
- » **Population:** 4 selected hospitals and clinics in Greater Cleveland: Cleveland Clinic, University Hospitals, Metro Health, and VA NEO Healthcare.
- » **R&D expenditure:** Total R&D expenditure includes R&D expenditure at 4 hospitals and clinics. For Cleveland Clinic, the total amount of research support was used as a proxy for the annual cost of research. For University Hospitals, R&D expenditure represents research funding to the UH clinical departments through the School of Medicine and the research conducted at UH Cleveland Medical Center, including clinical trials.
- » **Geography:** selected entities in Greater Cleveland.
- » **Other clarifications I:** R&D expenditure from private hospitals and clinics (Cleveland Clinic and University Hospitals) are included in R&D spending from private companies (sourced from the BERD survey).
- » **Other clarifications II:** Regarding revenue data, while MetroHealth System and University Hospitals report operating revenue, Cleveland Clinic presents operating income before accounting for interest, depreciation, and amortization, and Luis Stokes VA Northeast Ohio only discloses operating budget in its annual report. All this limits comparability.

Methodology Notes | NASA Glenn Research Center

- » **Source:** NASA John H. Glenn Research Center Economic Impact Study FY 2021. Up to February 2023, 2021 is the last year for which this report was available.
- » **R&D expenditure:** These expenditures include purchases in Northeast Ohio and expenditures on labor income paid to employees living in Northeast Ohio.
- » **Geography:** Since there is no information on R&D spending in Greater Cleveland, direct spending in Northeast Ohio (NEO) is considered for this report. NEO includes only eight counties: Ashtabula, Cuyahoga, Geauga, Lake, Lorain, Medina, Portage and Summit Counties.
- » **Other clarifications:** Note that the 2021 report presents direct spending in NEO and in Ohio in both 2021 dollars and 2022 dollars (NEO direct spending in 2022 dollars equals \$583.9 M and Ohio direct spending in 2022 dollars equals \$623.9 M).

Methodology Notes | Patenting Activity

- » Slides 10, 11 and 12 present the number of patents granted to 24 companies in Greater Cleveland. The selection of companies was drawn from an initial list of 40 innovative companies in the region.
- » Slides 10, 11 and 12 present worldwide patenting activity. Nonetheless, there may be instances where an entity chooses not to file its patents with the United States Patent and Trademark Office (USPTO), leading to their omission from the overall patent count.
- » Data on patenting activity was obtained from the Patent View advanced research data tool powered by the U.S. Patent and Trademark Office (USPTO). Some entities are listed under slightly different names in different states or places, likely because different subsidiaries of the same company are registered with different names. In addition, occasional typographical errors can cause inconsistencies in entity names. As a result, figures may underestimate the patenting activity of entities displayed under several different names.
- » Regarding slide 22, the total number of patents granted per year was obtained by adding the number of patents granted to headquarters or subsidiaries located in cities in Greater Cleveland that are part of the top 200 global locations by patent count since 2013. These cities are Cleveland, Akron, Solon, Mayfield Heights, and Mentor.
- » The list of top organizations (slide 22) ranks patents granted to a headquarter or subsidiary (assignee) located in any of the five cities mentioned above. For this reason, when the assignee (subsidiary or headquarter) of a patent granted is located outside the region or the U.S. (such as Nestlé and Bridgestone), it does not appear on the list.
- » During examination of a pending patent application or after the patent is granted, the owner of the patent may transfer ownership to another entity or party, through an "assignment". The receiving party (i.e., the assignee) is typically a company, university, research lab, or other entity that employs the inventor(s). It is possible that the inventor and the assignee are the same. The assignment of a patent is independent of inventorship.

Glossary

- » **Global R&D expenditure from companies:** This figure includes global R&D expenditure reported by companies to the U.S. Securities and Exchange Commission in Form 10-k, and in published annual reports. Many of these companies conduct R&D activities in several countries (e.g., Nestle), not only in the United States. Thus, we cannot expect this figure to be comparable to domestic R&D expenditure from the BERD survey.
- » **Greater Cleveland:** Cleveland includes 3 MSAs: Cleveland-Elyria MSA, Akron MSA, and Canton-Massillon MSA.
- » **R&D Intensity Ratio:** The R&D Intensity Ratio for companies is calculated as the ratio between R&D expenditure in millions in a selected geography and the number of firms in innovative sectors in that same geography. According to the BERD Survey, the most innovative sectors in the U.S. (the sectors with highest domestic R&D expenditure) are Manufacturing, Information, and Professional Services.
- » **R&D Expenditure / Sales Revenue:** The ratio was calculated as the division between R&D expenditure and the company's sales revenue (also called sales or net sales).
- » **Total domestic R&D expenditure:** Total domestic R&D expenditure in Greater Cleveland was estimated by adding R&D expenditures from (1) Private companies, (2) Academic institutions, (3) Public hospitals and clinics, and (4) NASA Glenn Research Center. Private hospitals (Cleveland Clinic and University Hospitals) were excluded to avoid double-counting, given that companies' data from the BERD survey includes these institutions. Note that this is an estimate, since data sources vary considerably.
- » **Research focus at hospitals and clinics:** The main research focus at hospitals and clinics is based on qualitative information from their annual institutional reports.