



RETHINKING CLUSTER INITIATIVES

CASE STUDY

UPSTATE, SOUTH CAROLINA

**CLEMSON UNIVERSITY
INTERNATIONAL CENTER
FOR AUTOMOTIVE RESEARCH
(AUTOMOTIVE)**

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B | Metropolitan Policy Program
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HIGHLIGHTS

GEOGRAPHY

Upstate South Carolina is a 10-county region that includes the Greenville metropolitan area and the Spartanburg metropolitan area (approximately 1.4 million people).

CLUSTER SIZE AND GROWTH TRAJECTORY

The automotive cluster contains 22,000 employees, 4.6 times the concentration of the U.S. overall, and 3.3 percent annual employment growth (1998-2015).

CLUSTER TYPE

Clemson University's International Center for Automotive Research (CU-ICAR) is an automotive cluster that is industry-based defined as BMW and the concentration of 223 automotive-related companies that concentrate in the Upstate region, including a mix of small, medium, and large businesses.

ORGANIZATIONAL STRUCTURE

Concentrated on a 250-acre campus, CU-ICAR focuses on university-based talent development and an applied research center associated with the automotive industry. CU-ICAR is operated by a center within the Clemson University's Office of External Affairs in partnership with the College of Engineering and the Clemson University Real Estate Foundation. It works in tandem with Greenville Technical College and the Upstate Alliance to support the automotive cluster.

RESOURCES AND KEY ASSETS

CU-ICAR offers North America's first advanced degree in automotive engineering and is uniquely industry-relevant, featuring endowed industry faculty chairs in addition to significant co-investment from university, industry, and state government. The center has 14 dedicated staff with an additional 46 staff at Clemson's Department of Automotive Engineering, along with \$300 million in total public and private investment.

BACKGROUND

The Upstate South Carolina economy has always made things. Like many cities in America's Southeast during the early 20th century, the Greenville-Spartanburg region was dominated by the textiles industry, earning the moniker "Textile Center of the World" in 1917. From that peak, however, overseas competition and mechanization created major job losses in the textile industry in the decades following World War II. Beginning about 40 years ago, local and state leaders began a push to diversify the regional economy through the attraction of new companies, industries, and capabilities, particularly in advanced manufacturing.

Today, the automotive cluster in the Upstate region is one of the largest and deepest in the nation. For decades, global companies like Bosch (automotive components) and tire manufacturers such as Bridgestone and Michelin have operated in South Carolina, bestowing a set of auto-related capabilities. But the major spark for the Upstate region's auto foothold came in 1992 when Spartanburg successfully beat out 250 other locations to land BMW's first manufacturing facility outside Germany. In an aggressive, coordinated courting, local and state government provided BMW with a \$150 million incentive package. Since then, BMW has created close to 9,000 jobs and invested \$9 billion locally. Its Spartanburg facility is now the company's largest in the world. In 2015, Volvo

announced a \$500 million investment in a new factory in Charleston, which it has since doubled to \$1 billion. Beyond BMW, the cluster consists of 232 auto-relevant suppliers that provide the parts, components, and supportive services that facilitate auto production. Most of these suppliers focus on branch manufacturing, but some are now also conducting research and development at their Upstate region facilities.

Business attraction-led cluster development is a somewhat risky strategy—as many bets on individual firms end up failing—but South Carolina's decision has paid off because of local and state investments in workforce training, supplier development, applied research, transportation and logistics infrastructure, and smart branding and promotion that have helped sustain and grow the automotive cluster over time. Many institutions contributed to these efforts—from the state's technical colleges to its local and regional economic development entities—but at the center of the Upstate region's automotive cluster is Clemson University's International Center for Automotive Research (CU-ICAR), a uniquely industry-facing talent development and applied research organization. This case profiles the emergence of CU-ICAR and its central role, along with the region's technical colleges and economic development organization, in supporting the Upstate region's automotive cluster.

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Rather than evolving gradually over time or being hidden from plain sight, the automotive cluster in the Upstate arrived with a bang. While the region's workforce had developed auto-relevant capacities in textiles and tires, the Upstate region's emergence in the automotive sector reflects the rare instance in which a corporate attraction strategy yielded the creation and development of an industrial cluster. In other words, South Carolina initially "identified and prioritized" the automotive cluster by betting big on BMW, with the rationale for spending significant public resources on an original equipment manufacturer (OEM) not only being the jobs created at BMW's facility, but also the expectation that BMW's suppliers would also cluster in the region and state.

Other Southern states pursued a similar OEM attraction strategy during the 1980s, most notably in Kentucky (Toyota) and Tennessee (Nissan). Labor and energy costs were lower in the south than in the traditional automotive states, such as Michigan and Ohio, making them attractive destinations for foreign OEMs. There was also political appetite for providing generous incentive packages for foreign firms that would deliver new industrial capabilities.

The BMW courting began in the late 1980s, when South Carolina Governor Carroll Campbell cold-called BMW to state its interest in hosting a new facility. Shortly thereafter, BMW made a determination that it would build an assembly plant in North America. After considering hundreds of locations, BMW selected Spartanburg in 1992, citing several reasons: the convenience of the eastern time zone for communications with its Munich headquarters, the state's technical college system, good transportation links to a deep-water port (BMW now exports 70 percent of its vehicles via the Port of Charleston), the labor environment (e.g., right-to-work laws and a moldable auto culture),

presence of some relevant suppliers (e.g., Michelin and Bosch), proximity to product and supplier markets, and a political environment that deeply wanted them (e.g., personal attention from the governor and a generous incentive package).

At the time, BMW was one of the largest corporate attractions in U.S. history, and almost immediately it became clear that the arrival of BMW was going to require ongoing engagement to actualize its transformative potential. One early example was the Clemson University College of Engineering's 2000 proposal to localize some of BMW's research and testing by co-investing in a commercial wind tunnel so that BMW, among other firms, could test cars in South Carolina instead of in Germany. While Clemson never built the wind tunnel, the discussions between the university, BMW, and other local employers such as Michelin and Timken revealed another local need: a larger supply of high-end automotive engineers. These initial conversations were one motivation for the creation of CU-ICAR.

In 2005, the state commissioned Michael Porter's Monitor Group to conduct a study on the state's overall competitiveness as well as viable industry opportunities. In that report, Porter and his team conducted cluster analysis and gathered information from over 500 industry, government, academic, and economic development leaders across the state, eventually focusing on four clusters: automotive, chemical products, textiles, and tourism.

According to that report, "clusters were selected according to several criteria: their competitive position of South Carolina's cluster vis-à-vis other regions around the country; number of employees; and geographic distribution across the state. The purpose of the cluster analysis was to gain a deeper understanding of the

issues, challenges, and opportunities in South Carolina, and to support several large clusters that have a significant economic impact on the state's economy."

Specifically, the Monitor Group analyzed overall cluster employment and employment growth, average wages and wage growth, and patenting intensity and patenting growth. Its findings concluded that South Carolina had experienced growth in the auto sector, but it was still in its early stages and had yet to reach critical mass. It cited as disadvantages relatively few advanced degree holders, a limited supply of skilled workers, and little interaction with local suppliers on product and process development.

In short, challenges around talent development and product and process innovation.

The Monitor Group study occurred *after* the conversations began around talent needs related to automotive engineering, and the study itself referenced the potential of CU-ICAR to support the automotive cluster even though the center was not operational yet. While CU-ICAR's development was already in motion, the report's findings were likely helpful in securing the buy-in of high-level stakeholders. The study had the buy-in from the governor and an advisory Council on Competitiveness that brought together leading business, education, and civic leaders from across the state.



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By the mid-2000s, the arrival of BMW and the findings from the Monitor Group study had identified and prioritized the cluster as a vital anchor for both the Upstate and South Carolina economies. It also was clear that the region would need to continue to adapt to distinguish itself from other Southern automotive states. Between the competitiveness assessment by the Monitor Group and conversations between Clemson and industry leaders, two industry needs emerged that, if addressed, could separate South Carolina from other competitors:

1. **Automotive engineering talent.** The region did not have the supply of automotive engineers necessary to support BMW's planned expansions and provide the capacity for BMW's supplier base to locate nearby.
2. **Applied, industry-relevant research.** While the Upstate region had developed a foothold in automotive production, it did not have an institution prepared to conduct industry-relevant research as digital technologies reshaped the automotive industry.

In 2003, Clemson University created the International Center for Automotive Research (CU-ICAR) to address both issues. Today, CU-ICAR's vision is "to be the premier automotive research, innovation, and educational enterprise in the world." Its mission is to "be a high seminary of learning, in the field of automotive engineering; lead translational research, with emphasis on industry relevance, and support excellence in basic research; contribute to high value job creation in South Carolina; and lead global thinking on the sustainable development of the automotive sector."

Education and training is the first element of CU-ICAR's mission. In 2007, the center began offering M.S. and Ph.D. programs in automotive engineering, the first program of its kind in

North America. As of 2015, the automotive engineering programs enrolled about 200 to 210 students combined, with about one-third in the Ph.D. program. The two-year M.S. curriculum covers a comprehensive set of competencies in automotive design, systems, and electronics. Participants in the doctorate program cover a similar set of topics at greater depth and typically graduate in three to four years. In the fall of 2017, the center launched an Automotive Engineering Certificate program for undergraduate students and non-degree-seeking industry members. The one-year certification requires four courses covering automotive product innovation, automotive systems, vehicle dynamics, and propulsion systems.

CU-ICAR's educational activities also now feature two partnerships to build a homegrown pipeline of automotive engineers within the K-12 system. The first program, All Girls Auto Know, is a partnership with the Southern Automotive Women's Forum to bring over 300 young women to CU-ICAR for a daylong event featuring industry-relevant employers and schools. The second is a partnership with Fisher Middle School, a science-, technology-, engineering-, art-, and math-focused school located on CU-ICAR's Millennium Campus. In addition to receiving tours of CU-ICAR, 40 middle school students have participated in the center's mentorship program.

CU-ICAR maintains an excellent faculty, including industry-endowed chairs in four core research areas. Current industry sponsors include BMW (chairs in systems integration and automotive manufacturing), Michelin (vehicle electronic systems integration), and Timken (automotive design and development). The endowed chairs have ensured that CU-ICAR is attracting professors whose research is at the vanguard of major technologies, such as autonomous driving, advanced sensing systems, human-

robot interaction, and intelligent manufacturing. These industry chairs are a significant element of the state of South Carolina's innovation and economic development strategy. In 2002, the South Carolina General Assembly agreed to appropriate up to \$200 million to match nonstate sources of investment in endowed professorships at Clemson, the University of South Carolina, and the Medical University of South Carolina. This investment has allowed the state's universities to create well-compensated professorships that attract leading faculty while drawing in private sector support.

Breakthrough innovations in automotive systems, processes, and technologies are the focus of CU-ICAR's unique immersive learning framework Deep Orange. Deep Orange puts students in the shoes of the research and development department of a major auto manufacturer. Working with faculty and industry partners, students design and produce a future vehicle concept over the course of 24 months. One recent project, sponsored by Toyota, was to develop a vehicle prototype that would appeal to the distinct wants and needs of young people living in future settings. Another project, sponsored by BMW, sought to reinvent the MINI for the U.S. market. Deep Orange provides students with industry-relevant training while addressing industry-relevant problems for private sector sponsors.

These education and training activities, especially Deep Orange, overlap with CU-ICAR's second mandate: **applied research**.

CU-ICAR offers 12 different models of industry engagement along with seven key strategic areas of translational research (Advanced Powertrain Systems, Automotive Systems Integration, Human Factors/Human-Machine Interaction, Manufacturing and Materials, Vehicle Performance, Vehicle-to-Vehicle Connectivity and Vehicle-Infrastructure Integration, and Vehicular Electronics).

Three models illustrate how CU-ICAR engages the private sector through applied, industry-relevant research.

- ▶ One model involves what CU-ICAR calls *vertical collaboration*, meaning that companies within different parts of the automotive value chain come together to define a research topic and use Clemson as a "collaboration broker and development partner." In practice, this model involves a situation such as the following: Michelin is interested in developing a new type of tire design called TWEEL, and BMW wants to understand if this technology can improve driving dynamics. Together, Michelin and BMW contract CU-ICAR to test the ride and handling of a Mini Cooper utilizing TWEEL technology. The industry partners and/or Clemson would own the intellectual property developed as part of this contract.
- ▶ A second model centers on *faculty-led research and development*. CU-ICAR's faculty have unique engineering expertise, such as in developing instruments that can measure dimensions at an extreme level of precision. Timken, a global manufacturer of bearings, is interested in a more effective instrument to measure raceways. Timken contracts directly with the faculty member to develop that instrument, with the intellectual property to be negotiated with the partner company.
- ▶ A third model involves *graduate student research and development*, in which students work with a company on a specific R&D project and are perhaps even directly employed by the company. For example, Dale Earnhardt, Inc. wants to improve the accuracy of the chassis in their racecars. Clemson assigned a graduate student to work at the company on that project for a specified period while still under the supervision of a Clemson faculty member, with an IP accruing to Clemson and licensing being negotiable.

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To deliver its applied research and training functions, CU-ICAR invested in a 250-acre physical campus in Greenville. Currently, the campus has six buildings concentrated in one “technology neighborhood.” The Graduate Engineering Center includes spaces for students, faculty, testing facilities, and conferences. BMW operates the Information Technology Research Center, at which it conducts R&D related to information technology applications in its cars. Nearby, the Center for Emerging Technologies offers office, administrative, and lab space to transportation, technology, and energy companies. Finally, Koyo Bearings, a Japanese-owned manufacturer of steering systems, driveline components, and bearings, operates its own building on the campus to conduct prototyping, product testing, and manufacturing process development. The campus is now planning the construction of a seventh building.

The campus’ master plan has room for four additional technology neighborhoods. In this

regard, CU-ICAR is more than a training and applied research initiative, but is also attempting to be an anchor for an ambitious technology campus for companies that may want to operate adjacent to the center’s facilities. The campus already houses a road simulation and climate test chamber, drive-on vehicle coordinate measurements, an engine performance facility, and machine shop. Industry partners have access to these facilities at minimal cost.

Sleekly designed with the LEED certification stamp of environmental approval, the campus also serves as the most prominent visual proof of the Upstate region’s presence in automotive technology development. The conference spaces have provided a backdrop for dozens of industry-oriented events, cementing the center’s role as a hub of global thought leadership within the industry. Visitors to CU-ICAR have included former U.S. Secretary of Commerce Penny Pritzker and dozens of international delegations.

ORGANIZATIONAL STRUCTURE

CU-ICAR sits under Clemson's Office of External Affairs and reports directly to the Vice President of External Affairs. The External Affairs office also oversees innovation campuses focused on technologies related to biomedicine and engineering, human genetics, and information technology. Clemson is a public land-grant university, and therefore funding for CU-ICAR must be included in the university's budget request to the state legislature.

CU-ICAR currently has 14 full-time staff, which includes a partnership office, an office of land and capital asset stewardship, operations, and two staff that run the center's component testing. These staff are responsible for the operations of the center itself and do not include the faculty and staff affiliated with the Department of Automotive Engineering. CU-ICAR's executive director is Nick Rigas, who

joined the center in 2018 after running Clemson University's Restoration Institute. He replaced Fred Cartwright, who served as executive director between 2013 and 2018 after spending decades at General Motors.

The Department of Automotive Engineering employs over 40 professors and supportive staff and operates under the College of Engineering, Computing, and Applied Sciences. In addition to the four endowed chairs, the department employs 11 professors and an additional 16 faculty members that have affiliations with other departments or serve in an adjunct role.

The final part of the CU-ICAR organizational structure is the Clemson University Real Estate Foundation (CUREF), a 501(c)(3) organization that manages planning and development of the 250-acre CU-ICAR property.



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Over 10 years after its founding, CU-ICAR has implemented a core set of educational programs and applied research functions and collocated those activities in a physical campus. Implementation required several investments from the state of South Carolina. First, the South Carolina Department of Commerce provided \$40 million to Clemson to fund the center. Second, the General Assembly passed the Research University Infrastructure Bond Act in 2004, which allowed the university to secure another \$70 million from public and private sources to build the campus' facilities and research infrastructure. In sum, CU-ICAR has secured investments totaling \$300 million, including:

- ▶ \$26.4 million from Clemson University and the Clemson University Real Estate Foundation
- ▶ \$95.5 million from state and local or other governments
- ▶ \$55.8 million from private industry and private developers
- ▶ \$36.0 million from state and private industry partnerships (50/50) in four engineering program endowed chairs
- ▶ \$19.7 million from equipment-related private industry
- ▶ over \$250,000 from fellowships & scholarships

Industry has invested in the campus through facilities development (e.g., BMW's technology center), the endowed chairs, and equipment provision. Three global firms—BMW, Michelin, and Timken—have been particularly important investors and validators for CU-ICAR. Today, CU-ICAR has 21 industry partners that call the campus home, 16 companies that have donated equipment, 13 companies that have sponsored fellowships for students, and 33 companies that have engaged in research partnerships.

Private sector support has been critical, but it is clear that the center would not exist without the support of government. The state government—most prominently the Department of Commerce—has made CU-ICAR a major priority along with the institutional resources of South Carolina's research university.

There are additional institutions within the Upstate region that have worked with CU-ICAR to develop the auto cluster. The technical college system in South Carolina was established with an explicit economic development mandate and is therefore uniquely industry-relevant, with the automotive industry being a seminal example. Technical colleges have been a major asset in tailoring training programs to high-demand jobs within the automotive sector.

Greenville Technical College, for instance, has collaborated with CU-ICAR on the Center for Manufacturing Innovation. That center focuses on training the next generation of advanced manufacturing production and engineering technicians and also features a 4,000-square-foot Vehicle Assembly Center (VAC) that provides research space for advanced manufacturing. The VAC is a unique partnership of CU-ICAR, Greenville Technical College, BMW, and Siemens. More broadly, the region's technical colleges offer auto-related degrees and certificates, including mechatronics, automotive technology, mechanical engineering with an auto focus, welding, machine tool technology, and lean manufacturing. The technical college system has also engaged automotive employers through its Apprenticeship Carolina program, which provides work-based learning opportunities for technical college students within the sector and has a solid track record of connecting students to jobs at the companies at which they apprentice.

Key infrastructure investments have also enabled the cluster's growth. Most prominently, the Inland Port Greer opened in 2013, which provides access to 95 million consumers within a one-day drive. Positioned along Norfolk Southern's main rail line and along the I-85 corridor, the inland port provides a unique intermodal logistics facility that can connect the Upstate region's manufacturers to the Port of Charleston as well as major East Coast and Southeast markets. In 2016, BMW's Upstate facility exported more cars than any plant in the United States, 86 percent of which were sent through the Port of Charleston.

The Upstate Alliance, the region's public-private regional economic development organization, has aggressively promoted the entire auto cluster to investors across the nation and the world, including leading the development of a regional trade and investment strategy that brought together leaders across the public, private, and university sectors to focus on key sectors such as automotive.

Various outcome metrics document the economic impact of CU-ICAR. The center:

- ▶ Graduated more than 400 students from its M.S., Ph.D., and certification programs. About one-quarter of those students are working in the state of South Carolina;

- ▶ Partnered with 33 firms on industry-relevant research;
- ▶ Attracted \$300 million in public and private investment;
- ▶ Created 720 jobs on the CU-ICAR campus; and was acknowledged as a best practice by the National Academy of Sciences, U.S. Department of Commerce, SSTI, the Association of Public and Land-Grant Universities, and Georgia Tech's Enterprise Innovation Institute.

In addition, while not directly attributable to CU-ICAR, BMW announced in 2017 a \$600 million expansion at its Upstate facility and the creation of 1,000 new jobs over the next four years.

Going forward, the center's leadership is considering how its capabilities can extend to companies and industries outside the automotive sector. For instance, manufacturers in many industries are interested in how robots and humans will be integrated in the factories of the future. CU-ICAR has examined this from the perspective of automotive companies, but it also has applicability to electronics or aerospace or machinery manufacturing.

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CONCLUSION

For over a decade, CU-ICAR has been expanding its pool of graduates, its physical footprint, and its roster of companies that it considers partners and co-investors. The center's rise has coincided with a continued expansion of the automotive cluster in Upstate South Carolina, led by multi-billion dollar investments by BMW that anchor the cluster with hundreds of related suppliers. CU-ICAR

is particularly notable for its use of industry-endowed professorships in key technologies related to the automotive industry and its rigorous, applied learning program to train students. For leaders in other regions and states, CU-ICAR offers an example of how a major research university, state government, and industry can co-invest in a shared asset that can differentiate a cluster from its competitors.



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