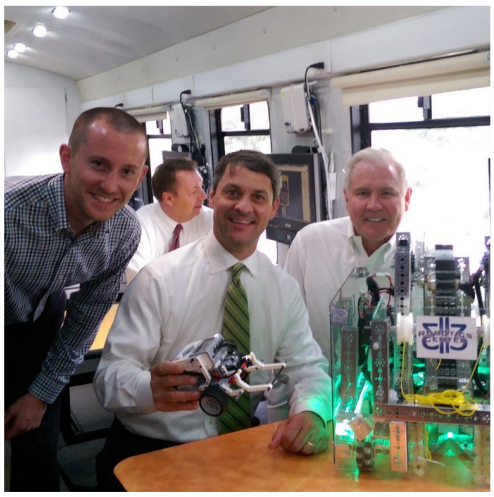
SOUTH BEND | ELKHART
REGIONAL PARTNERSHIP



Tides of Change:

Critical Investments Needed to Stimulate Long-term Economic Prosperity in the South Bend-Elkhart Region

Performed for: South Bend-Elkhart Regional Partnership
Performed by: TEConomy Partners, LLC
September 2018

TECONOMY PARTNERS LLC

TEConomy Partners, LLC is a global leader in research, analysis, and strategy for innovation-based economic development. Today, we're helping nations, states, regions, universities, and industries blueprint their future and translate knowledge into prosperity.

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Executive Summary

A Pressing Need—Changing the Economic Trajectory of the SBE Region

The South Bend-Elkhart (SBE) Region has a strong advanced manufacturing sector on which to build; but, the region's firms, like firms throughout the United States, are under tremendous competitive pressures. Maintaining and expanding the economic performance of advanced manufacturing in the SBE Region will depend on these firms' ability to innovate and move new processes and products into the market rapidly.

The SBE Region is thriving during the current economic expansion, making strong advancements in growing jobs, increasing wages, and driving down unemployment to record-setting lows. However, citizens have not forgotten the economic hardships the region experienced during the Great Recession, and fully realize that these gains can quickly be erased during periods of economic downturn. In fact, the underlying root causes of the previous economic decline have not changed:

- The rate of population growth continues to lag both the State of Indiana and the nation, further exacerbated by the levels of out-migration, particularly of the region's most talented individuals;
- Educational attainment levels continue to lag the state and nation, a limiting factor in creating added value to existing industry as well as expanding into emerging areas of opportunity; and
- The region is highly reliant upon key industry clusters that are highly vulnerable to business cycles, and the lack of industrial diversification raises the concern of many community leaders that the region will not be able to weather the next economic downturn.

An analysis of the region's innovation ecosystem, including an examination of the SBE Region's performance against five peer benchmark regions and the nation, finds the SBE Region lagging behind in key facets required for innovation-led economic development, including the following:

- The educational attainment of residents, with lower shares of workers with the higher education requirements needed to enter middle- and high-skilled jobs;
- Occupations related to STEM (science, technology, engineering, and math) such as scientists, engineers, information technology (IT) specialists, and math and statistics experts;
- Patent awards, a key measure and signal of regional innovation;
- Venture capital and federal commercialization funding for emerging high-potential new companies;
- Employment in "young" firms and the high-growth start-ups that will spawn the next generation of regional innovation and wealth-generation.

Despite this current position, the region has both a base of existing activity and the momentum on which to build; and this regional assessment and strategy is intended to address these challenges. The SBE Region is recognizing the importance of its innovation assets, including the evolution of one of its oldest—Notre Dame—as it is successfully shifting from an institution primarily focused on undergraduate education to a major research university among the nation's top tier and one firmly committed to advancing its home region as a leading partner. In addition to Notre Dame, the region is

home to a number of higher educational institutions that are generating new graduates and that represent a major combined asset in high-skilled talent generation.

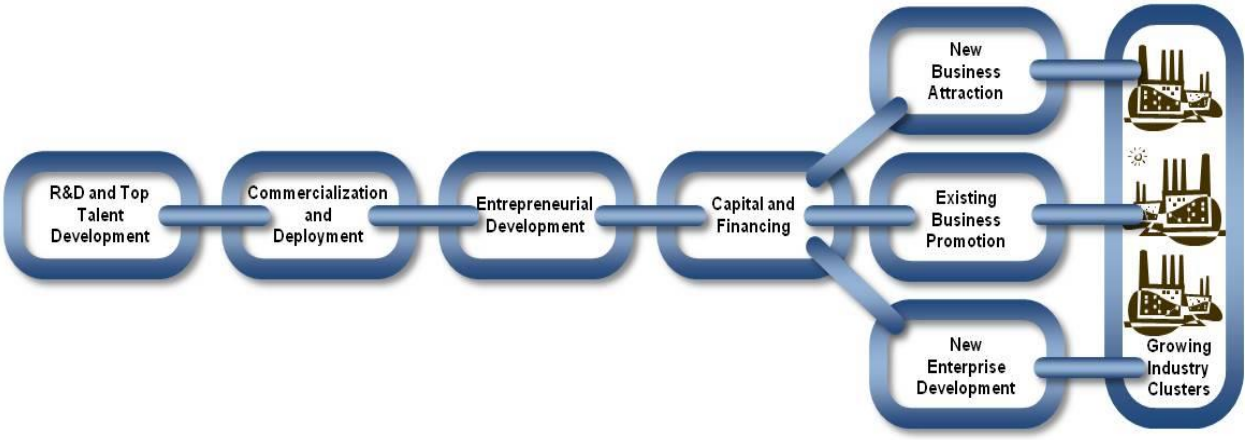
The key to long-term economic growth and community prosperity will be in determining how best the region's innovation assets can be linked to its industrial base, both existing and emerging, to help ensure economic sustainability.

Drivers of the SBE Region's Future Economy

Economic development in general is not easy to achieve; innovation-based economic development is an even greater challenge. For innovation-based economic development to occur, an entire interconnected sequence of positive economic factors must be in place to strengthen the drivers of, and ecosystem for, advanced industries and traded sectors, namely, innovation, capital, and talent. If any stage of this innovation continuum either inadequately addresses the economic needs or is missing altogether, a sustainable innovation-driven economy able to generate quality jobs is unlikely to develop. To succeed, it takes a high-functioning innovation ecosystem (Figure ES-1) that is able to accomplish the following:

- Translate R&D activities into new products;
- Move technology commercialization into high-growth businesses; and
- Provide a competitive advantage in which emerging firms develop and stay, existing businesses grow, and out-of-state businesses are attracted.

Figure ES-1. A Robust Innovation-Based Economic Development Ecosystem



Source: TEConomy Partners, LLC.

The SBE Region must be willing to support collaborations between private and public sectors, serving as facilitator and catalyst to be able to develop an impactful innovation continuum. Its economic development initiatives must be focused on both existing and emerging industries in new and different ways. Economic experts argue that, to compete in the future, a region must have an economic base composed of firms that do the following:

- Constantly innovate based on knowledge;
- Maintain their competitiveness by focusing on innovation, time to market, quality, and cost;
- Integrate the technological revolutions into the workplace, both in terms of how they do business and in terms of the businesses and markets in which they choose to participate;

- Network with other firms and institutions, establishing alliances by collaborating; and
- Reward and invest in their primary resources: talented individuals and teams.

Strategic Recommendations to Position the SBE Region for Long-Term Economic Growth

The SBE Region has a critical role to play in ensuring that its innovation ecosystem is structured to leverage disruptive change and adapt to it. To accelerate the region's economy, it is proposed that the SBE Regional Partnership focus its efforts on three strategic priorities. Table ES-1 provides a summary of the recommended strategic plan to position the SBE Region for long-term economic growth and prosperity.

Table ES-1. Recommended Strategies and Actions to Position the SBE Region for Long-Term Economic Growth

Strategy	Targeted Actions to Pursue
Strategy One **Foster the Infusion of Advanced Innovation Processes, Products, and Techniques into the SBE Region's Advanced Manufacturing Industries, Starting with the Mobility Meta-Cluster and its Supply Chain**	**Action 1:** Create an Institute for Industry Innovation, in partnership with regional industrial leaders, University of Notre Dame, Purdue, and other regional institutions of higher education, that focuses on infusing advanced innovation processes, products, and techniques into the SBE Region's industrial base.
Strategy Two **Catalyze the Entrepreneurial Ecosystem to Diversify the Economy and Drive Future Economic Growth**	**Action 2:** Expand the role of the SBE Regional Partnership to provide entrepreneurial support services to innovative start-up companies and coordinate with other entrepreneurial initiatives in the region.
	Action 3: Create an indigenous pipeline of risk capital funds to invest in entrepreneurial efforts in the region.
Strategy Three **Develop, Retain, and Attract the Talent that the SBE Region's Existing and Emerging Industries Demand**	**Action 4:** Create and scale experiential learning opportunities to connect students with industry as well as retrain incumbent workers.
	Action 5: Launch a marketing/branding campaign to attract alumni back to the SBE Region by creating an Alumni Recruitment Program.

The ***primary strategic recommendation*** is the creation of an Institute for Industry Innovation, in partnership with regional industrial leaders, University of Notre Dame, Purdue, and other regional institutions of higher education, that focuses on infusing advanced innovation processes, products, and techniques into the SBE Region's industrial base.

This is needed because of the fundamental shift that is occurring throughout the smart mobility industry cluster and its supply chain as new automation, data collection, and materials technologies are being increasingly incorporated into traditional assembly and processing operations. Next-generation manufacturing and materials represents the broad portfolio of technologies that are expected to revolutionize the way that products are made, ranging from incorporation of more advanced raw materials inputs to analytics-driven predictions of useful life for downstream finished parts and systems.

The technology platforms that make up next-generation manufacturing and materials are aligned with advancing and consolidating the traditional steps of the manufacturing process and include the following:

- Digital product design and modeling, which allows manufacturers to design and test in virtual environments with both the manufacturing process and use life of products in mind.
- Novel advanced materials with highly customizable properties and highly precise means of being shaped into parts and components while maintaining durability and consistency.
- New manufacturing processes that replace traditional subtractive manufacturing, revolving primarily around the scaling of technologies in additive manufacturing and three-dimensional (3-D) printing.
- Industrial automation and robotics systems that perform increasingly complicated fabrication and assembly tasks.
- Embedded sensor and instrument networks within production systems and machinery that collect and report data in real time to help diagnose and dynamically react to problems as well as build out large-scale analytics tools for manufacturing operations.
- Postprocessing and finishing technologies that rely on combinations of novel finishing materials such as coatings and polymers, sensing and materials analysis, and automation to ensure consistency and quality in products across varying production run sizes.

Taken together as a whole, the convergence of these technology platforms within modern manufacturing operations will lead to a more wholly integrated "smart manufacturing" environment, with information from all stages of the production process interacting and creating feedback loops that allow a production line to "tune" itself without any stoppages or retooling requirements. These smart production environments also represent a new vision for the role of manufacturing in supporting the mobility industry, where just-in-time orders and highly variable production run sizes can be efficiently delivered at increasingly local scales to customers of all sizes. Leaders in adopting innovations in this space can expect to gain significant advantages over competitors in terms of producing value-added products and reducing operating costs.

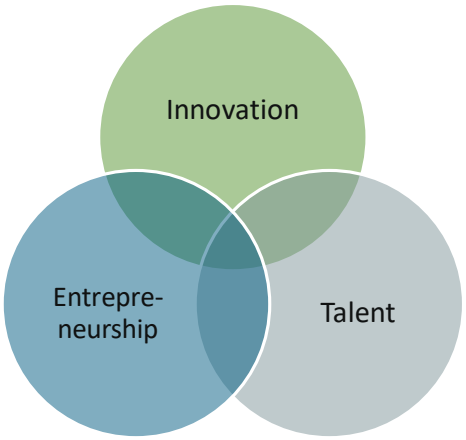
To ensure global competitiveness, the region, in partnership with institutions of higher education and industrial leaders, should create an Institute for Industry Innovation that focuses on infusing advanced innovation processes, products, and techniques into the daily operations of the SBE Region's industrial base. The Institute should focus on cross-disciplinary areas of technology convergence working to ensure that the innovation needs of existing regional industry are met, new opportunities to diversify the economy emerge, and talent is generated and linked to regional economic drivers.

The core activities of the Institute would include four specific efforts/functions:

- Public-private-academic applied development projects;
- Operational assistance in identifying areas of improvement, streamlining processes, and ultimately increasing competitiveness;
- Commercialization of innovation through entrepreneurial endeavors; and
- Placement of talent into regional firms to help meet industrial innovation needs.

While the creation of the SBE Institute for Industry Innovation is the anchor recommendation, it is not alone sufficient to transform the SBE Region's economy. To accelerate the region's economy, it is proposed that the SBE Regional Partnership focus not only on advancing innovation, but also on the following:

- Catalyzing the entrepreneurial ecosystem to diversify the economy and drive future economic growth; and
- Developing, retaining, and attracting the talent that the region's industry demands.



A Call to Action

The SBE Region has the opportunity to leverage its current momentum by making critical investments today that will enable the region to "leap forward" and become a leading job- and wealth-generating economy over the next decade. In today's global knowledge-based economy, the recipe for economic success is quite simple—the SBE Region needs to focus its economic development investments to ensure not only that its existing industry drivers can raise their level of competitiveness and added value, but also that it can identify new drivers of innovation to improve the region's economic prospects. This investment strategy is designed to address these challenges and identify the elements and ingredients to successfully position the region to mitigate its challenges, build on its strengths, seize its opportunities, and put into action a set of strategies that catalyze economic and community prosperity.

The analysis suggests that, to truly transform its economy, the region must do the following:

- Foster the infusion of advanced innovation processes, products, and techniques into the SBE Region's Advanced Manufacturing Industries, starting with the Mobility Meta-Cluster and its supply chain;
- Catalyze the entrepreneurial ecosystem to diversify the economy and drive future economic growth; and
- Develop, retain, and attract the talent that the SBE Region's existing and emerging industries demand.

Taking advantage of these opportunities requires key strategic investments that will require the broad support and collaboration of the entire region. By working together, the opportunity for the SBE Region to grow its economic base and increase community prosperity is substantial. If successful, it is expected that what will emerge are public-private-academic partnership initiatives that will advance the region for the coming decades.

A Call to Action

Innovation Drives Long-Term Economic Prosperity

Since this nation's inception, the U.S. economy has been able to sustain economic growth and standard of living increases for its population. This progress has occurred largely through the innovation of Americans and a sustained ability to achieve ever-higher levels of productivity in agriculture, industry, and commerce. Over the last several decades, however, it has become increasingly apparent that America's innovation dominance has been in a state of decline leading to economic loss. Global competition is eroding the economic leadership of the United States, as indicated by concerning trends:

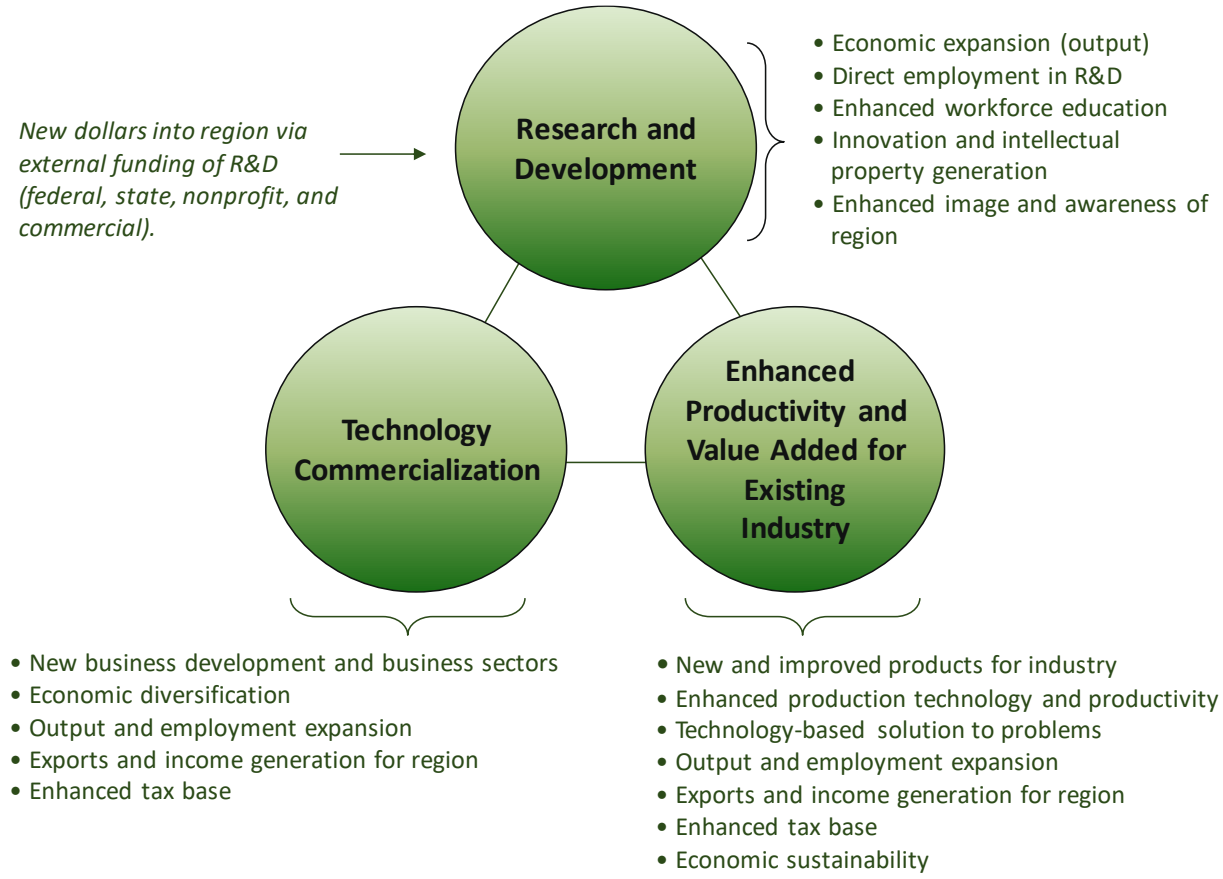
- As the Council on Competitiveness has reported through its *National Innovation Initiative*, globalization has changed the competitiveness paradigm. "Low cost, high quality and rapid product deployment no longer create market advantages for companies. Rather, they represent the baseline requirements just to enter the game. Prosperity in this global economy is tied to the ability to innovate—to translate knowledge into new products, processes, and services."[1]
- K–12 educational performance in the United States has fallen behind that of most competing developed nations. In terms of educational performance per dollar spent, U.S. educational productivity has been in a fairly dramatic decline—rather than increasing as it should.[2]
- The United States has a negative balance of trade that is growing. The country is consuming many more goods produced by competing nations than it is in turn selling overseas. In 2017, the U.S. deficit was $568.4 billion, increasing from $504.8 billion in 2016 as imports increased more than exports. As a percentage of U.S. gross domestic product (GDP), the trade deficit was 2.9 percent in 2017, up from 2.7 percent in 2016. It is important to note that the trade deficit is not a short-term anomaly; it is now a sustained trend.[3]

At the heart of the problem is a nation that is falling behind in its ability to innovate. As illustrated in Figure 1, innovation and technological prowess are key drivers of economic growth, high-quality jobs, and rising standards of living—explaining not only the differences in economic growth among nations, but also at the level of state and regional economies. As the World Economic Forum in its highly touted *Global Competitiveness Report* explains:

> *In the long run, standards of living can be expanded only by technological innovation.… This requires an environment that is conducive to innovative activity, supported by both the public and the private sectors.*[4]

[1] Council on Competitiveness, *Imperative for Innovation: 2001*.
[2] http://www.pewresearch.org/fact-tank/2017/02/15/u-s-students-internationally-math-science/.
[3] https://www.bea.gov/index.php/news/blog/2018-03-07/2017-trade-gap-5684-billion.
[4] World Economic Forum, *The Global Competitiveness Report 2010–2011*, page 8.

Figure 1. Innovation-Led Development is a Key Driver of Economic Growth



Source: TEConomy Partners, LLC.

Within an environment of stiff and increasing competition, it is important for a region to be able to make informed decisions regarding the right strategic and sound investments for its economic future. **Research indicates that the key determinant of the long-term economic prosperity of any region lies within its ability to innovate and enhance economic output based upon that innovation.** Generating an economic ecosystem conducive to innovation is increasingly central to the future sustainability of a region's economy.

The U.S. economy has always been carried upon the back of inventiveness and creativity, so the "innovation economy" per se is not a new phenomenon; rather, it is more accurate to say that innovation has increased in importance as the primary impetus of economic growth and competitiveness. Two fundamental forces are driving the preeminent importance of technology and knowledge advancement as the determinant of economic success:

- The first of these is the rapidly accelerating pace of scientific discoveries and the technologies that these discoveries give rise to (advances in genetics, for example, have dramatically accelerated the discovery process in the biosciences). The opportunity to speed the discovery

and development processes, in concert with the ability to protect and profit from intellectual property (IP), is leading to an innovation race among competing countries, regions, and states.

- The second fundamental force is the globalization of world markets and the increasing pressure to maintain a high-wage/high-skill employment base through consistently staying ahead in technology and productivity.

The South Bend-Elkhart (SBE) Region has a strong advanced manufacturing sector on which to build; but, the region's firms, like firms throughout the United States, are under tremendous competitive pressures. Maintaining and expanding the economic performance of advanced manufacturing in the SBE Region will depend on these firms' ability to innovate and move new processes and products into the market rapidly.

Within this Innovation Economy, the SBE Region Continues to Lag Behind

The SBE Region is thriving during the current economic expansion, making strong advancements in growing jobs, increasing wages, and driving down unemployment to record-setting lows. However, citizens have not forgotten the economic hardships the region experienced during the Great Recession, and fully realize that these gains can quickly be erased during periods of economic downturn. In fact, the underlying root causes of the previous economic decline have not changed:

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The key to long-term economic growth and community prosperity will be in determining how best the region's innovation assets can be linked to its industrial base, both existing and emerging, to help ensure economic sustainability.

Intent/Purpose of Study

Recognizing the need to change the region's economic dynamics, regional thought leaders have come together in the spirit of regional cooperation to seize the current economic momentum and focus on improving key facets of the innovation ecosystem from workforce and talent, to diversified industry growth, to creation of a culture and ecosystem where entrepreneurs and new businesses can thrive. To this end, the South Bend-Elkhart Regional Partnership commissioned this study to develop an investment plan that will help secure the SBE Region's economy for long-term, sustainable economic growth and community prosperity.

TEConomy Partners, LLC (TEConomy) (see sidebar) was retained to assist with the analysis to bring an independent, expert assessment and knowledge of best practices to develop the strategic recommendations. TEConomy has a proven track record in conducting rigorous and robust assessment studies of innovation ecosystems in numerous states and regions—including Arizona, Connecticut, Georgia, Indiana, North Carolina, Michigan, Ohio, Utah, and Virginia—that inform the targeting of innovation-led growth opportunities found in a region as well as strategic actions to further innovation-based development.

In 2015, TEConomy Partners, LLC was launched as an independent company, transitioning the complete staff and capabilities of the Technology Partnership Practice from Battelle Memorial Institute, one of the world's largest nonprofit research organizations. TEConomy comprises key senior staff from Battelle's Technology Partnership Practice who have worked together for over 15 years, operating as a full-service assessment and strategy group. Its principals have a 25-year track record developing strategic plans and providing economic impact analyses. Its clients include industry associations, state and local governments, universities, nonprofit organizations, business development groups, and foundations around the world. At a national level, TEConomy's public policy services help its clients, such as BIO and PhRMA, navigate a range of issues, needs, and opportunities.

Line of Sight from Regional Industry Clusters to Innovation, Technology, and Market Opportunities

Modern innovation-based economic development posits that, to optimize regional potential and elevate innovation-led growth, those regions fortunate enough to have institutions of higher education, research innovation assets, and technology drivers must work to identify connections between them and the local industrial strengths and opportunities. The SBE Region, with hundreds of highly skilled PhD-level faculty, 11 postsecondary institutions, 40,000 college and university students, and more than $200 million in annual academic research and development (R&D) activity, is in a unique position to excel and advance its innovation economy. This section of the report identifies and recommends areas for potential linkages between the region's industry clusters and its emerging university research and innovation activity. The chapter begins by identifying existing regional industry clusters as well as other emerging technology opportunities. It then turns to the rise of regional university research at Notre Dame and draws potential connections or a "line of sight" linking research strengths to industry strengths and opportunities with connections to growing markets and applications.

SBE Regional Industry Clusters: Generating Wealth and Driving Economic and Income Gains in the Region

Manufacturing plays an outsized role in the SBE regional economy where more than one-in-three jobs are in the sector, 3.4 times greater than the national average.

Put simply, the SBE Region makes things. In an era when U.S. manufacturing has diminished in overall importance to the economy, the three-county region in North Central Indiana has an outsized concentration in manufacturing. More than one-in-three regional jobs are in the manufacturing sector (35 percent), 3.4 times greater than the national average. Looking across the region's broad base of "traded industries"—those industries that export goods and services beyond the region and therefore drive wealth creation, income, and economic growth—they are clearly manufacturing-dominant.

Industry clustering is an often-utilized framework and organizing principle for understanding interrelated groups of traded industries that drive a regional economy. According to *The Economist*, "clustering is the phenomenon whereby firms from the same industry gather together in close proximity."[5] This simple explanation of a cluster is much more complex in reality, requiring a highly interconnected ecosystem for cluster firms to not only agglomerate, but to thrive and hold together. Industry firms most typically cluster geographically where an ecosystem is ripe with key ingredients, including access to and sharing of common markets and supply chains, shared workforce and talent access and needs, and proximity to research infrastructure and assets including research universities and labs. For modern technology-oriented clusters, attraction is often enhanced when characterized by

[5] "Clustering," *The Economist,* August 24, 2009. Accessed online at: http://www.economist.com/node/14292202.

a high quality of place and livability. By clustering, an industry and its firms can achieve higher productivity and competitive advantages through collaboration and operational efficiencies.

TEConomy has refined its approach to identifying and defining industry clusters through decades of technology-based economic development (TBED) experience and a proven methodology that involves the following:

- Examining how the region's traded industries are evolving at the most detailed industry levels. This enables understanding of specific activities and targets based on size, relative concentration/specialization, and recent trends, particularly against national performance.
- Refining the analysis based upon the specific activities of leading firms in traded industries. TEConomy leverages information from corporate databases, company websites, and direct outreach to understand products, services, and applied technologies and where they fit relative to other companies and industries in the region, including with respect to regional supply-chain relationships.

The SBE Region's Industry Clusters

The assessment of the industrial structure of the SBE Region's economy identified 14 industry clusters (Table 1).[6] While this is surely a large number for a region of relatively modest geographic size, the project team found it most useful in understanding and clearly identifying regional strengths and economic drivers to maintain a more refined level of detail in the clustering. While a number of clusters are highly interrelated in terms of vertical integration and supply chains, the examination of leading companies in the region often found them serving multiple end markets; therefore, it was not prudent to fully integrate or combine them together. For example, regional producers of cabinets and furniture serve markets for both recreational vehicles (RV) and traditional family homes; metals fabricators provide materials to local manufacturers of RV and other vehicles but also to commercial lawn and garden companies outside the state.

Other clusters identified are more nascent in their development, modest in size, but emerging in their development within the region. These include technology- and knowledge-driven clusters in IT and life sciences. These high-wage and innovative industries are demonstrating growth within the region and are important for stakeholders to monitor and nurture into the future, but are perhaps not yet at a level to warrant the primary emphasis of other more dominant and mature industry clusters.

The region has a "specialized" concentration in 9 of its 14 industry clusters. Regional specialization is measured using a location quotient that measures a state or region's share of employment in a specific industry or cluster relative to that for the nation overall. So, a location quotient of 1.0 means a region matches the national average concentration. A location quotient that exceeds 1.0 indicates a greater concentration than the nation, and a location quotient of 1.20 or greater is considered to be *specialized* in that industry.

[6] For detailed definitions of the industry clusters, see Appendix A to this report.

Table 1. Establishment and Employment Overview, SBE Regional Industry Clusters, 2016

North Central IN Industry Clusters	Establishments, 2016	Employment, 2016	Location Quotient, 2016	Employment Change, 2010-16
Total Private Sector	**11,213**	**246,103**	**1.00**	**19%**
RV, Travel Trailers, & Campers	71	24,742	166.49	55%
Transportation, Distribution, & Logistics	1,145	15,701	0.95	8%
Metal Processing and Products	278	11,076	3.43	39%
Hospitals and Health Services	71	10,797	0.89	9%
Polymers, Plastics, and Rubber	141	9,829	5.79	38%
Motor Vehicles	103	9,467	4.91	0%
Private Colleges and Universities	10	9,204	3.57	10%
Manufactured Buildings & Building Products	162	9,025	6.38	58%
Cabinets, Furniture, & Related Products	92	5,193	6.49	46%
Other Transportation Equipment	15	2,315	2.11	41%
Life Sciences	39	2,226	1.06	11%
IT Services	139	1,052	0.23	39%
Micro-Electronic Components	19	1,004	1.21	12%
Engineering/Environmental Technical Services	113	881	0.24	9%

Source: TEConomy's analysis of Bureau of Labor Statistics, Quarterly Census of Employment and Wages (QCEW) data; enhanced file from IMPLAN.

The SBE Region's large and leading RV, travel trailers, and campers cluster has a location quotient that is quite literally "off the charts," registering at 166, or 165 times the national average, reflecting its production of more than 80 percent of the nation's RVs. A large employment base connected, at least in part, to the RV industry via supply-chain relationships with very high degrees of regional specialization include (1) cabinets, furniture, and related products and (2) manufactured buildings and building products.

Other specialized clusters include materials strengths in metals as well as polymers, plastics, and rubber; transportation-related clusters in motor vehicles and other transportation equipment (which includes motorcycle and boat manufacturing, and aerospace parts); and a modest-sized cluster producing micro-electronic components.

SBE Regional Colleges and Universities: A Key Asset in Talent and Innovation Development

- Ancilla College
- Bethel College
- Goshen College
- Holy Cross College
- Ivy Tech Community College
- Indiana University South Bend
- Lake Michigan College
- Purdue Polytechnic Institute
- Saint Mary's College
- Southwestern Michigan College
- University of Notre Dame

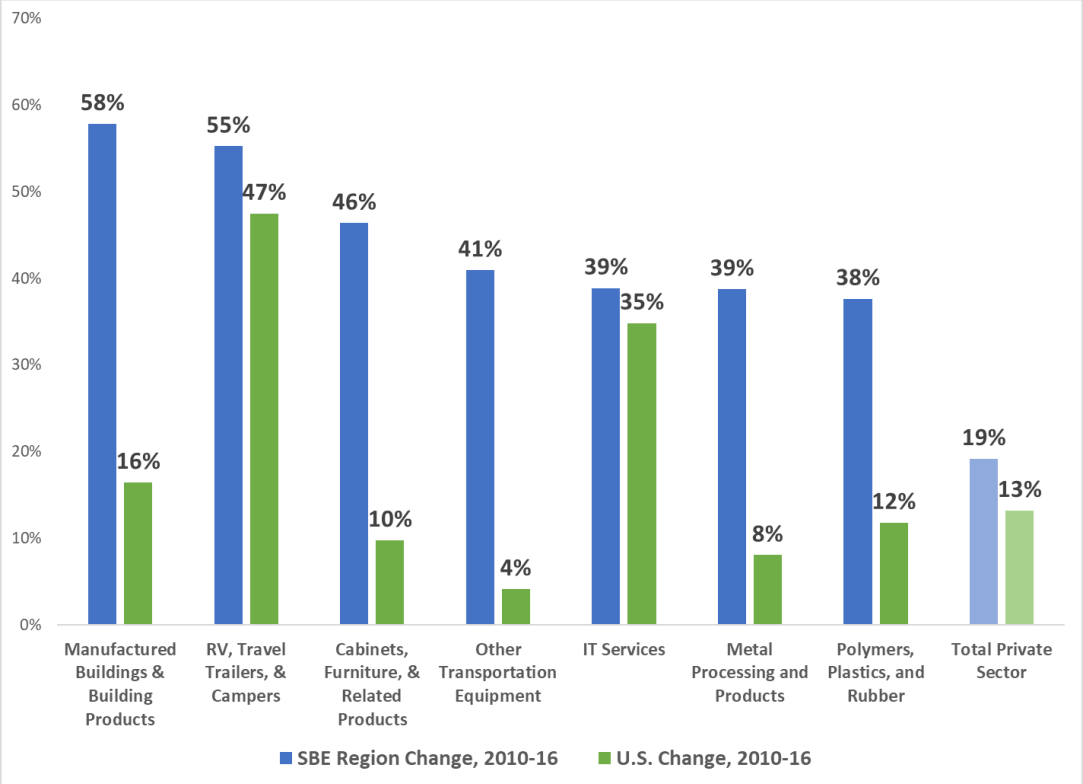
While not a traditional "industry" cluster per se, the region's high concentration of colleges and universities stands out as unique and a vital asset providing access to key regional, ecosystem-enhancing

resources in both talent, with a cadre of high-skilled and well-educated faculty and researchers, and talent development, as well as research and innovation. The SBE Region is home to 11 colleges and universities (see text box). As a combined cluster of employers in the Indiana counties, the private institutions employ 9,204 and have an extremely high location quotient reaching 3.57 for the region.[7]

The SBE Region's Industry Cluster Growth and Wage Trends

The region has had strong employment growth during the current expansion, reflected in the high-growth nature of its industry clusters, with all but one growing its jobs base, half outpacing overall regional private-sector growth (19 percent), and 10 of the 14 clusters growing faster in the region than in the nation (Figures 2a and 2b).

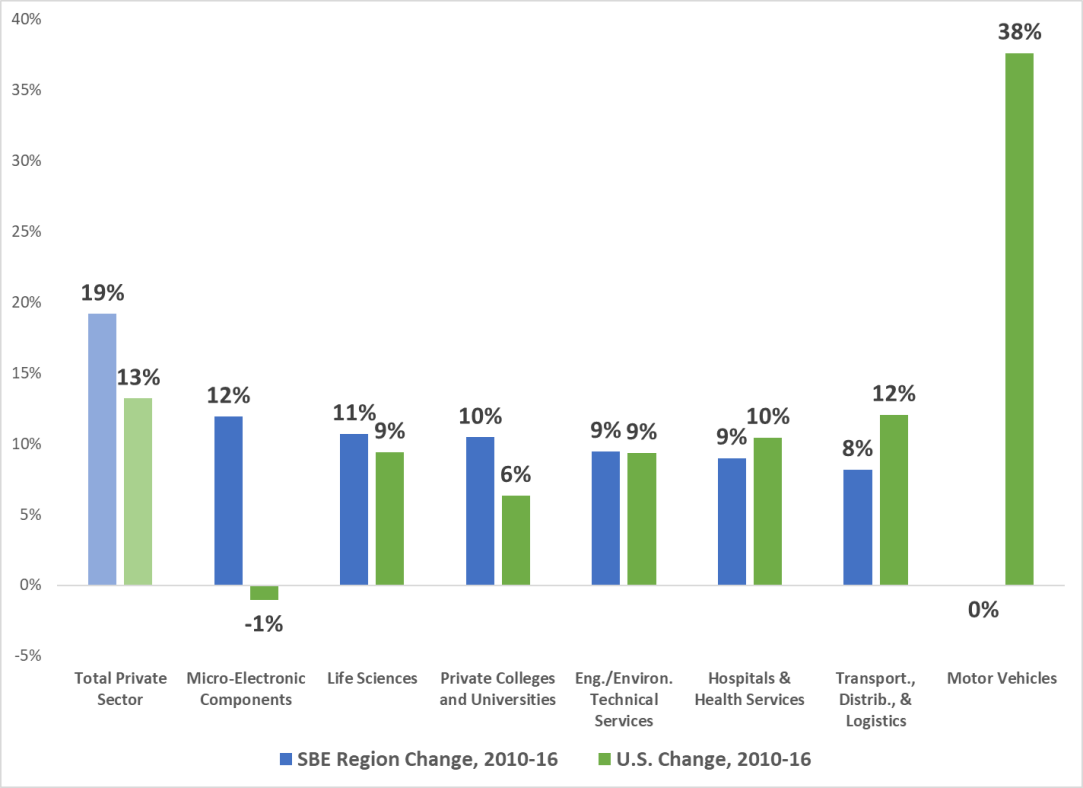
Figure 2a. Employment Change during the Economic Expansion, SBE Region vs. the United States, 2010–2016 (1 of 2)



Source: TEConomy's analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

[7] When public institutions are included, the employment totals for the SBE Region reach 10,753.

Figure 2b. Employment Change during the Economic Expansion, SBE Region vs. the United States, 2010–2016 (2 of 2)



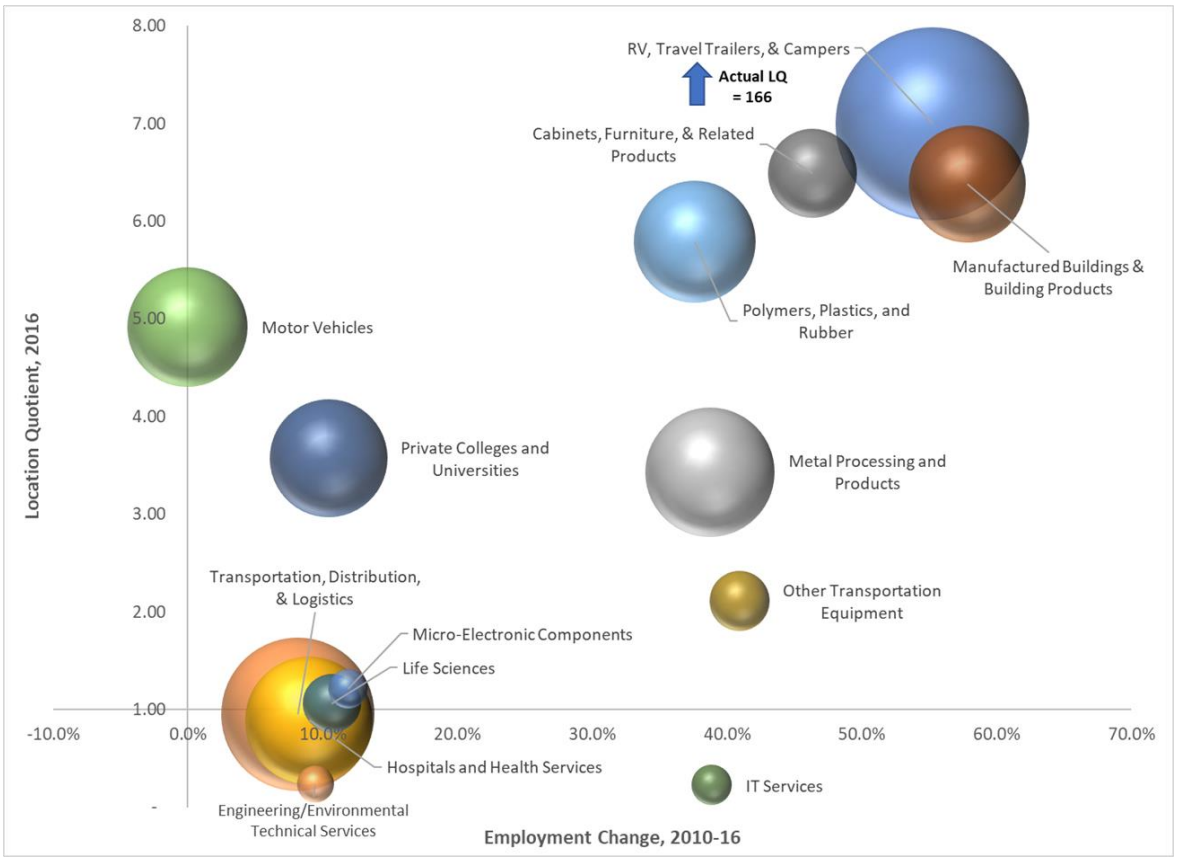
Source: TEConomy's analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

The region's strong growth profile and highly specialized industry clusters stand out in Figure 3. This graphic plots the position and relative performance across each of the 14 clusters using three key variables—employment size/level (the size of the bubble), relative concentration using a location quotient (the vertical axis), and growth/trend during the economic expansion (horizontal axis).

A bubble chart is typically shown using four quadrants since in most economies, even during economic expansions, some clusters will experience net employment declines. The SBE Region in this current economic growth period stands out because all of its clusters are positioned to the right of the vertical axis, i.e., all have grown (the exception being motor vehicles, where employment has been flat).

The concentration of clusters in the upper-right quadrant highlight the large base of regional "stars" that are mature, specialized in the region, and continuing to add jobs, many at a very high rate relative to their lower employment bases at the end of the last recession. Those industries positioned in the lower-right quadrant are "emerging" in the region, growing their employment base but not yet matching the national average in their employment concentrations.

Figure 3: SBE Regional Cluster Employment Size, Concentration, and Recent Trends



Source: TEConomy's analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.

Regional stakeholders have a clearly identified, bottom-line goal of increasing the region's per capita income. Analysis conducted by the SBE Regional Partnership published in the *Ensuring Prosperity* report found:[8]

> *"Fifty years ago, per capita personal income in the region was above the national average. Today, the South Bend-Elkhart Region's per capita income is $42,946, 87 percent of the national average."*

A central goal then of the Regional Partnership's Industry Growth and other Committees is to focus on those industry clusters that pay, on average, higher wages. During the last 7 years for which the data are available, from 2009 through 2016, the SBE Region has outpaced the nation in per capita personal income growth, with a compound annual growth rate (CAGR) of 4.6 percent compared with 3.2 percent for the nation. Assuming the national growth rate were to remain at its current annual pace, the SBE Region would have to increase its CAGR by 0.2 percentage points to 4.8 percent to catch up to the national per capita level by 2025. This would be no small achievement, however, as it would represent exceeding $65,000 in per capita income in 7 years.

[8] South Bend-Elkhart Regional Development Authority and South Bend-Elkhart Regional Partnership, "Ensuring Prosperity for the South Bend-Elkhart Region," February 2018.

A majority of industry clusters pay wages that exceed, on average, those for the overall private sector (Table 2). Reflecting the challenge raised by the Regional Partnership with respect to lagging regional per capita incomes, however, the average wages for the clusters are nearly all lower than for the clusters nationally. The exceptions are in the regional RV, travel trailers, and campers cluster, where the region is the global hub for this activity and average wages are 22 percent higher; and in cabinets, furniture, and related products where the region has a modest wage premium. Regional wages lower than national averages are reflective of multiple factors, including lower costs of living and doing business (often cited by regional employers as a key strength); but, they are also reflective of the occupational makeup of clusters and the value-added nature of regional clusters compared with the nation. Significantly lower average pay (beyond that explained by regional cost differences) does signal lower value-adding activities. The highest-paying regional industry clusters have wage differentials of roughly $30,000 per year, on average. So, while these high-wage clusters should be nurtured, wage rates indicate that they are quite different in their activities relative to their national counterparts.

Table 2: Average Annual Wages for Regional Industry Clusters, SBE Region and the United States, 2016

Regional Industry Clusters	SBE Region	U.S.	SBE Region Wages as Share of U.S.
IT Services	$ 71,028	$ 108,528	65%
Engineering/Environmental Technical Services	$ 66,198	$ 96,313	69%
Other Transportation Equipment	$ 64,859	$ 92,852	70%
Life Sciences	$ 63,578	$ 99,762	64%
RV, Travel Trailers, & Campers	$ 62,953	$ 51,414	122%
Private Colleges and Universities	$ 58,234	$ 61,995	94%
Transportation, Distribution, & Logistics	$ 54,442	$ 66,936	81%
Metal Processing and Products	$ 49,906	$ 57,900	86%
Hospitals and Health Services	$ 48,303	$ 61,101	79%
Motor Vehicles	$ 45,689	$ 61,830	74%
Total Private Sector	**$ 44,175**	**$ 53,507**	**83%**
Cabinets, Furniture, & Related Products	$ 43,790	$ 43,366	101%
Polymers, Plastics, and Rubber	$ 43,206	$ 56,438	77%
Manufactured Buildings & Building Products	$ 41,868	$ 49,570	84%
Micro-Electronic Components	$ 41,153	$ 103,238	40%

Source: TEConomy's analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN

As the region targets higher-wage clusters to raise per capita incomes, those that are significantly greater than the private sector average, say 10 percent or higher, should be targets of opportunity for raising regional incomes more significantly. Based on the data shown in Table 2, these "high-wage" clusters would include IT services; engineering/environmental technical services; other transportation equipment; life sciences; RV, travel trailers, and campers; private colleges and universities; transportation, distribution, and logistics; and metal processing and products, at almost $50,000 per year and above. The exciting aspect for the current regional positioning is that these clusters, in general, have demonstrated strong growth, and though they are modest in size, there is emergence in high value-adding sectors such as IT services, engineering services, and life sciences, three sectors that diversify the regional manufacturing economy.

Expanding the Regional Context: Southwest Michigan as a Key Part of the Region

The South Bend-Elkhart Region has long been more broadly associated with its Michigan neighbors across the border in a region encompassing 47 smart connected communities in Northern Indiana and Southwest Michigan. The region has long associated its economy with that of the Southwest Michigan counties of Berrien and Cass, and the project team has developed both an economic and benchmarking analysis that incorporates expanded analysis for the broader, five-county region so as to provide useful intelligence to this important, broader regional context.

Detailed industry employment data were examined for the additional two Michigan counties to understand how, if at all, these additional county economies alter the industry cluster landscape. In the assessment, the counties did not significantly change how the regional clustering should be shaped. In fact, the industrial composition of the Michigan counties is quite similar, reinforcing and expanding on SBE regional cluster strengths in most areas, including in life sciences; metal processing and products; transportation, distribution, and logistics; motor vehicles; micro-electronic components; and others.

In addition to bolstering the SBE regional clusters, there has been identified, and reinforced through discussions with Michigan's regional stakeholders, a unique one-company dominant cluster—in home appliances—based in Benton Harbor (Berrien County) with Whirlpool's World Headquarters, which includes R&D activities in a technology center, though no longer includes manufacturing operations. Benton Harbor has been at the forefront of Whirlpool's shift toward expanding connected product lines with the Internet of Things (IoT).

For data tables and charts presenting the industry cluster information for the five-county region, see Appendix A to this report.

Identified Regional "Meta-Cluster": Mobility

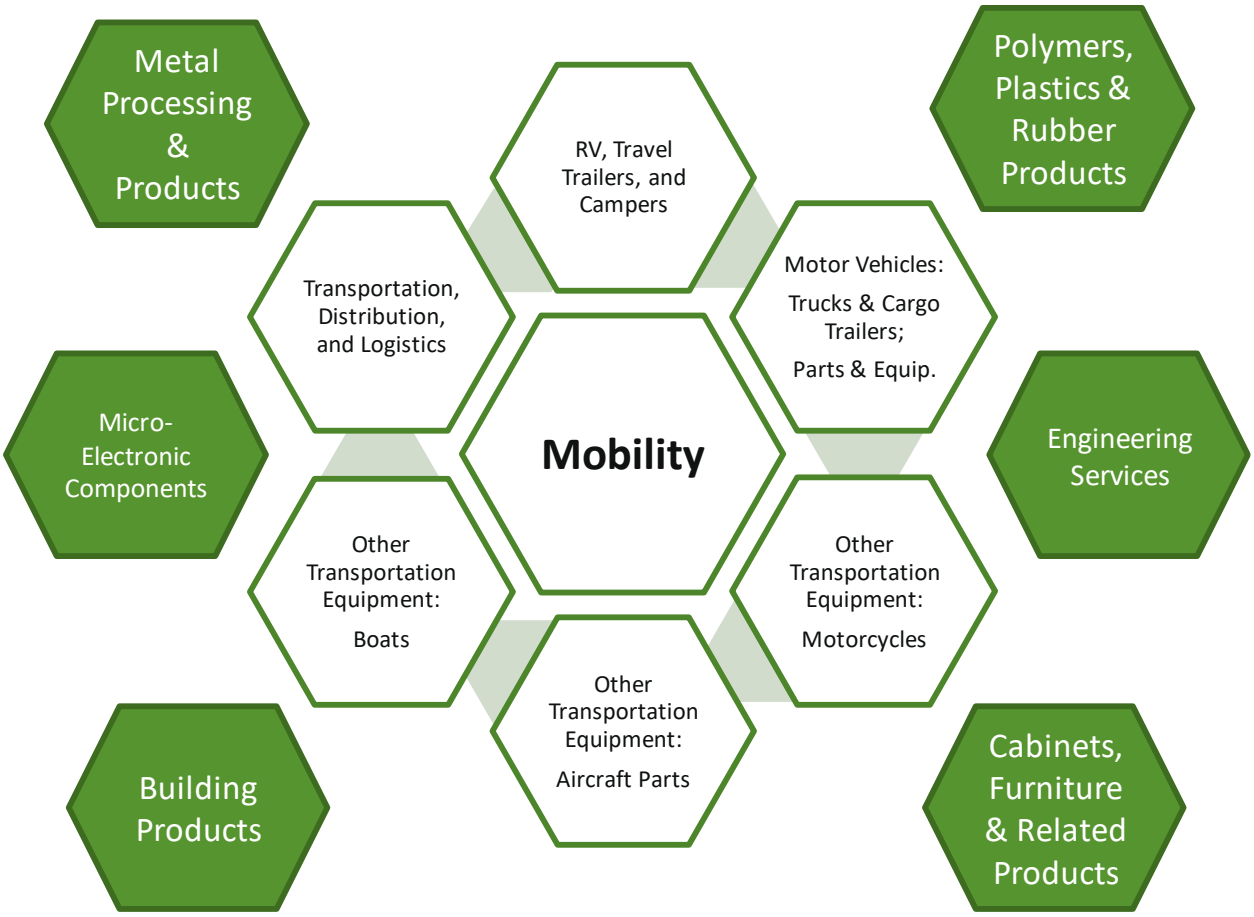
When examined at a macro scale, the majority of industry clusters in the SBE Region themselves cluster around a common theme or "meta-cluster," which TEConomy has characterized as "mobility." A large and highly concentrated swath of the region's companies, jobs, and innovation are in market, production, and technology spaces that center around transportation and mobility-related areas. The following regional product and company examples shed light on this theme via direct connections to mobility in its various forms and applications:

- RVs: Thor Industries in Elkhart, a global leader in the cluster affiliated with numerous brands and models
- Motor Vehicles, Trucks: AM General in South Bend, well known for its civilian Hummer and military Humvee
- Boats: Boat Holdings, LLC in Elkhart (recently acquired by Polaris); with pontoon brands including Bennington, Godfrey, Hurricane, and Rinker
- Motorcycles: Janus Motorcycles in Goshen
- Aircraft Parts: Honeywell Aerospace in South Bend, manufacturing wheels and brakes for aircraft
- Racing Tires: Hoosier Racing Tire in Lakeville
- Transportation, Distribution, and Logistics: Crown Equipment in Elkhart, supplying lift trucks, forklifts.

In addition, "indirect" clusters and companies in the region are connected to the over-arching mobility theme, shown as the more peripheral green shapes in Figure 4. Companies such as Patrick Industries, Lippert Components, General Stamping & Metalworks, and others directly serve the region's mobility manufacturers, but are also at their core non-transportation companies and are further diversified (to varying degrees) in providing products and services to other industries and markets.

When summing the industry establishments and employment associated with the inner, "direct" mobility clusters, the region reaches more than 1,300 establishments and 52,000 jobs or 21 percent of total private-sector employment in the SBE Region. Combining the outer, more indirect clusters brings the establishment total to more than 2,100 and employment exceeds 89,000 jobs or 36 percent of the private sector. And, while not all of these jobs are directly or solely connected to mobility-related products or markets, the vast majority are, and this industry market and technology theme is predominant across the region.

Figure 4. SBE Regional Industry Clusters and Their Common Theme: Mobility



Source: TEConomy Partners, LLC.

The mobility cluster largely encompasses the region's capabilities and competencies in advanced manufacturing. Many of the region's companies are using and leveraging advanced technologies to enhance and improve their production processes and products. Regional industry has embraced automation and has become a national leader in the installed density of industrial robots.

The Brookings Institution recently assessed the geographic landscape of installed robots in the United States, with robots defined to include "automatically controlled, reprogrammable machines" that are capable of replacing labor across different tasks.[9] The clustering of installed industrial robots concentrates in a few regions, particularly the Midwest, reflective of the auto industry, which, according to the study, uses almost half of all industrial robots. The study finds that the Elkhart-Goshen metropolitan area is the leading U.S. region in terms of installed industrial robot density, with a total of 4,355 industrial robots in 2015, reflecting a 20 percent annual growth rate from 2010 through 2015. The metro region, by 2015, had nearly 36 robots per thousand workers.

Brookings' findings are reflective of the highly automated advanced manufacturing sector in the SBE Region where employers cite a clear "ROI" for installing robots and embracing automation in their

[9] Mark Muro, "Where the robots are," Brookings Institution Metropolitan Policy Program, August 2017.

production environments. Employers, in discussions with TEConomy, have cited the extremely tight labor market as a current motivator for automation (as a potential substitute for labor) and view industrial automation as largely a complement to the workforce today.

A recent study by the Brookings Institution finds the Elkhart-Goshen metropolitan area is the leading U.S. region in terms of installed industrial robot density, with a total of 4,355 industrial robots in 2015, reflecting a 20 percent annual growth rate from 2010 through 2015. The metro region, by 2015, had nearly 36 robots per thousand workers.

Despite, however, the high concentration of production activities, the embracing of automation technologies, and the breadth of mobility-related strengths, from an innovation perspective, the regional mobility meta-cluster has limited depth and activity. Analysis of the region's patent activities over more than 8 years (2010 to early 2018) reveals limited IP generation among the region's mobility-related manufacturers.

As Table 3 illustrates, Notre Dame accounts for 12 percent of regional awarded patents "assigned" to a specific company or organization. Following that, among those with 10 or more patents during the 8-year period, only Lippert Components, Dometic, and Atwood Mobile (now part of Dometic) among SBE Region–headquartered companies are within the mobility space; and these companies would fall within the "indirect" segment of the mobility meta-cluster. Among companies headquartered elsewhere, assigned regional inventions to Honeywell (aircraft wheels, brakes) are connected with the aerospace mobility context; and Crown Equipment (forklifts, lift trucks) are in the material moving/handling space. Across this group of leading regional innovators, the aforementioned companies account for only about 10 percent of assigned patents, a modest total for such a dominant regional meta-cluster.[10]

[10] It is important to note that other mobility-related companies have been awarded patents; however, this analysis is limited to those companies with 10 or more during this 8-year period.

Table 3. Leading Patent Assignees with SBE Regional Locations, 2010–Early 2018

Leading Patent Assignees with Regional Locations, 2010 to Date	Number of Assigned Patents
Main Location in Northcentral Indiana Region (Assignees with 10+ Issued Patents)	
The University of Notre Dame Du Lac, Notre Dame, IN	167
CTS Corporation, Elkhart, IN	73
Lippert Components Inc., Elkhart & Goshen, IN	67
Elkhart Brass Manufacturing Company Inc., Elkhart, IN	31
NIBCO Inc., Elkhart, IN	23
Dometic Corporation, Elkhart, IN	21
Earthway Products Inc.,Bristol, IN	15
Logistick Inc., South Bend, IN	15
Vast Power Portfolio LLC, Elkhart, IN	14
AmSafe Commercial Products Inc., Elkhart, IN	13
Atwood Mobile Products LLC, Elkhart, IN	12
Shield Restraint Systems Inc., Elkhart, IN	11
Significant Branch Location in Northcentral Indiana Region (Assignees with 10+ Issued Patents)	
Bayer HealthCare U.S., Whippany, NJ (Mishawauka & Elkhart, IN)	66
Honeywell International Inc., Morristown, NJ (South Bend & Plymouth, IN)	33
Hubbell Incorporated, Shelton, CT (South Bend, IN)	13
Crown Equipment Corporation, New Bremen, OH (Elkhart, IN)	10
Total, Assigned Patents Connected to Northcentral Indiana	**1,372**

Source: TEConomy's analysis of data from Clarivate Analytics's Derwent Innovation patent database.

The mobility meta-cluster is mature and large-company dominant with a lack of emerging new potential high-growth companies receiving venture capital investments or SBIR awards. Among the regional firms receiving venture funding or Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR) awards, none are in the mobility or related manufacturing or technology applications space.

The findings from the industry innovation analysis of the mobility meta-cluster are concerning. While the region is succeeding in its current high-growth mode among existing large employers, there is relatively modest innovation activity in the form of patents and no companies showing high-growth potential via venture capital funding or federal commercialization awards. While in the midst of a strong economic expansion, it is difficult to look back to the pain of the prior recession, the region needs to find ways to diversify and enhance its product offerings and innovation profile to help mitigate future downturns. These findings signal a need in the region to boost opportunities for innovation connections that leverage regional innovation and technology assets that include university research and perhaps deeper connections to innovative companies in other emerging areas, such as the data analytics and IoT specialists seen in the region and indicative of emerging opportunities.

Notre Dame's Emerging Research Strengths—A Transformative Economic Innovation Driver

Notre Dame is emerging as a major research university:

- The University has grown its R&D base by nearly 150 percent in just 9 years through a strategic, planned transition.
- By 2016, University R&D exceeded $200 million annually.
- Notre Dame now stands among the elite group of top-quartile U.S. research universities.

The SBE Region has long had a concentration of reputable academic institutions from which to draw talented graduates. Over the last decade, however, the region has seen the transformation of Notre Dame, one of its longest-standing, highly valued regional assets, from an institution focused primarily on undergraduate education into a major research institution.

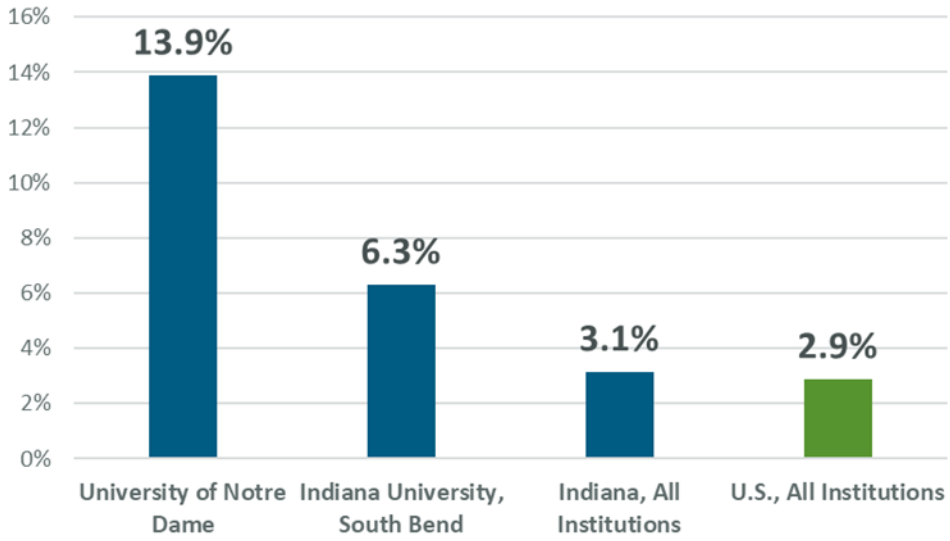
The SBE Region now has more than $200 million in annual university R&D expenditures, nearly all at Notre Dame, which has been making strategic research investments and increasing its R&D base by nearly 150 percent in just 9 years (Table 4 and Figure 5). From 2010 through 2016, Notre Dame has seen almost 14 percent annual growth in R&D expenditures, nearly five times the growth rate of its university counterparts nationally. Indiana University South Bend has also seen its R&D position increase at a strong rate, though from a much smaller base of existing activity, reflective of its more primary focus on education.

Table 4. Academic R&D Expenditures for SBE Regional Universities, 2016 ($ in thousands)

Academic Institution	Non-Science & Engineering Total	Science & Engineering Total	Total, All R&D
Indiana University, South Bend	$89	$1,385	**$1,474**
University of Notre Dame	$27,029	$175,187	**$202,216**

Source: TEConomy's analysis of National Science Foundation (NSF), Higher Education R&D Survey.

Figure 5. Average Annual Growth in Academic R&D Expenditures, 2010–2016



Source: TEConomy's analysis of NSF, Higher Education R&D Survey.

In terms of specific areas of sizable research activity and fields of strength, Notre Dame now has many areas that are both sizable in sheer dollar terms but also highly concentrated at the University relative to national averages (as measured by a location quotient for R&D spending, see Table 5 with relative strengths in red font). The fields presented in Table 5 are sorted by those that are most likely to have potential alignment with local industry clusters and the region's manufacturing base, though one could make arguments for potential linkages throughout the research portfolio.

Table 5. University of Notre Dame R&D Expenditures by Field, 2016

Field	Expenditures ($ Thousands)	Location Quotient	% of Total
Fields Potentially Aligned with Local Industry			
Biological and Biomedical Sciences	$27,149	0.74	13.4%
Chemistry	$25,089	5.02	12.4%
Aerospace/ Aeronautical/ Astronautical Engineering	$24,224	9.74	12.0%
Electrical/ Electronic/ Communications Engineering	$20,628	2.91	10.2%
Physics	$16,322	2.73	8.1%
Chemical Engineering	$10,250	4.11	5.1%
Civil Engineering	$10,169	2.71	5.0%
Computer and Information Sciences	$9,309	1.59	4.6%
Business Management and Business Administration	$6,190	3.38	3.1%
Mathematics and Statistics	$4,419	2.30	2.2%
Metallurgical and Materials Engineering	$3,169	1.46	1.6%
Other Engineering	$1,514	0.24	0.7%
Agricultural Sciences	$993	0.11	0.5%
Health Sciences	$316	0.01	0.2%
Other Academic Fields			
Humanities	$13,844	11.30	6.8%
Other Sciences	$8,544	2.82	4.2%
Psychology	$5,995	1.75	3.0%
Other Non-S&E Fields	$5,028	1.76	2.5%
Political Science and Government	$2,709	2.50	1.3%
Economics	$1,749	1.57	0.9%
Sociology/Demography/Population Studies	$1,620	1.14	0.8%
Visual and Performing Arts	$1,021	2.55	0.5%
Law	$946	1.76	0.5%
Other Social Sciences	$535	0.19	0.3%
Anthropology	$484	1.78	0.2%
Total, All R&D	**$202,216**	**1.00**	**100%**

Source: TEConomy's analysis of NSF, Higher Education R&D Survey.

The University's strengths are further identified and refined by an analysis of research publications in peer-reviewed journals. Similar to R&D expenditures, strengths are identified (and, in this case, limited

here to those with the greatest potential for regional industry alignment) where there is a sizable volume (100+ publications) as well as a specialized regional concentration (specialization value of 1.20+).

The examination of research publications from 2010 through early 2018 identified 13,129 peer-reviewed publications with an "author" connected to the SBE Region. These publications include journal articles and reviews and proceedings papers. Like the overall R&D expenditure activities, Notre Dame accounts for nearly all of these publications (94 percent).

Key research publications strengths for potential regional industry alignment (100+ publications; regional specialization value of 1.20+) include the following:

- Chemistry: Inorganic Nuclear; Physical; Organic; Multidisciplinary; Analytical; Medicinal
- Computer Science: Theory Methods; Interdisciplinary Applications; Hardware Architecture; Software Engineering; Information Systems; Artificial Intelligence
- Engineering: Civil; Electrical/Electronic; Chemical
- Life Sciences: Parasitology; Tropical Medicine
- Automation/Control Systems
- Math/Statistics: Several areas of concentration
- Mechanics
- Nanoscience/Nanotechnology
- Telecommunications.

Strategic Research Investments (SRI). Notre Dame has arrived at its current position through a deliberate, strategic, and multifaceted approach to growing its research enterprise. The University has been in "investment mode," focusing internal resources on very specific areas, referred to as Strategic Research Investments (SRIs), which include the following:

- Advanced Diagnostics and Therapeutics;
- Big Data/Data Analytics;
- High-Performance Computing;
- Nanotechnology;
- Environmental Change Initiative;
- Turbomachinery (including its Turbomachinery Laboratory);
- Institute for Advanced Study (cross-disciplinary for the study of "Big Questions");
- Eck Institute of Global Health;
- Energy (including renewable energy); and
- Harper Cancer Research Institute.

Most of the impressive growth of the University's funded research is tied to the SRI areas and associated entities including institutes and centers affiliated with many of these areas.

Notre Dame has complemented its SRI investments with a "cluster hiring" process referred to as the "Advancing Our Vision" or AOV initiative. These targeted areas, which are now reaching the hiring goals established by the University, are not necessarily tied solely to research initiatives, though they

represent key complementary areas of emphasis and strength. The 10 AOV initiatives are in the following:

1. Math: Topology and Quantum Field Theory
2. History: Global History
3. Chemical and Biomolecular Engineering
4. Economics
5. Computational and Data Science and Engineering
6. Nuclear Physics
7. Stem Cell: Bridging the Gap Between Stem Cell and Society
8. Analytical Sciences and Engineering
9. Applied and Computational Mathematics and Statistics
10. Advanced Circuits.

Looking across the key academic R&D concentrations, research publications, and targeted investment areas for growth and advancement, Notre Dame has a number of strength areas and thematic strengths to draw from and to potentially connect with industry. **Notre Dame's evolution as a research university is still underway, however, and as it continues to build and transition its research enterprise, the nature of its research will likely shift toward the more "applied" end of the research spectrum**. Based on NSF survey data, compared with other institutions in the top quartile of research spending, Notre Dame's research is

- much more "basic" in nature, with 96 percent of research activity characterized as such in 2016, with just 4 percent characterized as "applied" and 0 percent in "development"; this compares with other top universities tilted much more toward applied research (27 percent) and development (9 percent); and
- less funded by industry as a share of all sources of funding, with Notre Dame at 2.9 percent versus 5.9 percent for the top-quartile average.

Considering this rapidly evolving nature of Notre Dame, there are clear areas of opportunity to *potentially* connect with industry, but this line of sight is not as clear as it may be for a university with extensive existing industry collaborations and applied research, or one with more existing local connectivity. The exciting aspect, however, is Notre Dame's genuine intent to connect and to expand opportunities locally. The University is itself in a high-growth and investment mode and eager to expand with local research and innovation outreach and connections.

Line-of-Sight Opportunities

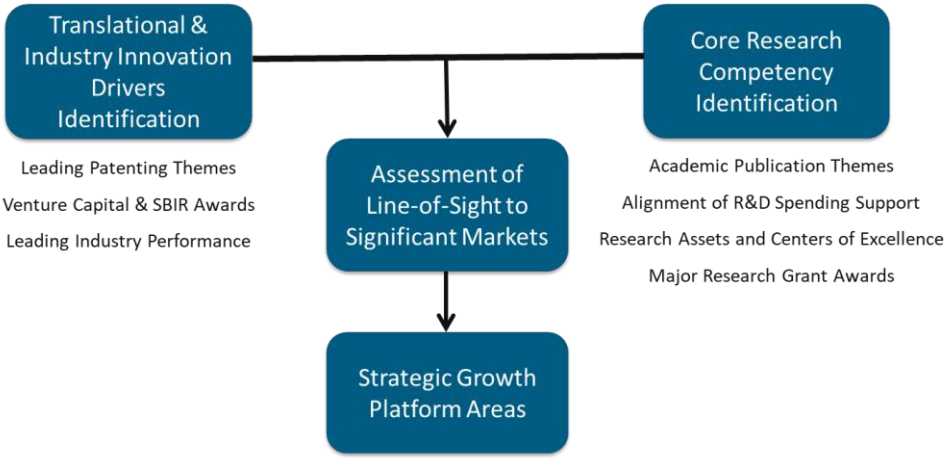
In today's global economy, where knowledge and innovation are the driving forces for economic competitiveness, a key challenge facing regions is to be able to identify the innovation opportunity assets across its academic and industrial base that can build specialized areas of expertise and differentiate the region as a leader in technology commercialization and innovation-led development to advance the economy.

In an interesting paradox, the more globally integrated the world economy becomes, the more a region's R&D assets and the ability of its innovation ecosystem to translate those assets into new

products and new businesses matter. These areas of localized strengths in R&D assets reflect the core competencies around which industries innovate and grow around specific regions. The concept of core competencies is now widely understood as a critical factor for industries to be competitive. According to Hamel and Prahalad in their widely acclaimed business strategy book, *Competing for the Future*, "Core competencies are the gateways to future opportunities. Leadership in a core competence represents a potentiality that is released when imaginative new ways of exploiting that core competence are envisioned."[11] Core competencies can be thought of as "bundles of skills and technologies" that enable innovation and growth.

With an understanding of the SBE Region's innovation assets across its research institutions and industry, it is now possible to examine where the region is best positioned to differentiate itself. These opportunities reflect the intersection, or "line of sight," where the region has the know-how and capacity to grow in the future. Figure 6 presents the overall approach and the specific metrics used in this assessment to identify a "line of sight" to strategic opportunity areas that consider the market pull of leading advanced industries found in the SBE Region and the technology push from the region's university research capabilities.

Figure 6. Line-of-Sight Approach for Identifying Strategic Growth Opportunities for the SBE Region



Areas where the SBE Region has ***real, differentiating potential***

Source: TEConomy Partners, LLC.

The following narrative outlines those areas of opportunity that provide the greatest potential for future economic growth in the SBE Region.

The Smart Mobility Opportunity

At the root of the SBE Region's mobility meta-cluster is manufacturing expertise that leverages talent and capital, increasingly in the form of industrial robotic systems and automation. Regional manufacturers, however, are at varying points along a spectrum of operational sophistication and

[11] Gary Hamel and C.K. Prahalad, *Competing for the Future*, Harvard Business School Press: Boston, MA, 1994, p. 217.

technological integration; and, meanwhile, there is a wave of new process manufacturing technology and capability approaching. Globally, there are major forces at work driving next-generation manufacturing or "Industry 4.0" including shifts toward flexible manufacturing operations, increasing demand for product customization, and changes in the cost effectiveness of technologies such as additive manufacturing. Currently, many next-generation process manufacturing technologies that will enable mobility and other advanced manufacturing verticals are at a nascent scale globally; they are projected to grow at extremely rapid rates, signaling a key moment for manufacturers to take advantage of early adoption and the advantages of moving first among competitors. Overviews of some of these key process manufacturing technologies are interspersed within this section, along with market size and growth projections, where available. And, while not all provide a current, clear direct line of sight from regional industry to regional university research, these areas are important for consideration on regional connections and partnering.

Beyond process technologies, the mobility meta-cluster more directly has a broad context associated with a wide range of technologies, markets, and entire industries. Technology and market applications and challenges span also a range of near- and longer-term opportunities. Existing and emerging market opportunities in the mobility or "smart mobility" space that may soon, or in the longer-term, be opportunities within the region include the following:

> "Within a more complex and diversified mobility-industry landscape, incumbent players will be forced to compete simultaneously on multiple fronts and cooperate with competitors."
>
> --McKinsey & Co.

Near- to mid-term potential market and technology needs and opportunities:

- **Fuel efficiency enhancements:** According to IBIS World, fuel price swings during the last 5 years have motivated R&D investments among RV and motor home manufacturers to increase fuel efficiency.[12] Consumer preferences and bottom-line operations costs for fuel-intensive vehicles are pushing manufacturers in this direction as well. Lighter-weight materials are being incorporated into RVs to influence better fuel efficiency and provide a preferred product to consumers. Technologies have been developed in the past for long-haul trucking that demonstrate potential solutions for RVs or light trucks for regional manufacturers—Airtab Fuel Savers, for example, are vortex generators that cut down on vehicle drag, save on fuel, and enhance vehicle stability and, hence, safety. They were rooted in National Aeronautics and Space Administration (NASA) innovation around aerodynamics and fluid dynamics and have proven to be low cost, low maintenance, and have advanced fuel economy. A regional connection with Notre Dame's Flow Physics group with specializations in these same NASA-related competencies could develop these types of product and technology solutions.
- **Advanced materials:** The evolving materials space for vehicles is interrelated with fuel efficiency needs and transitions toward hybrid-electric and electric vehicles. Cars have a history of more than 100 years, but only in the last quarter of this timeline have advanced materials such as aluminum, magnesium alloys, and carbon fiber composites been integrated into mass production to replace steel. These advancements helped to cut vehicle body and chassis weights

[12] Devin Savaskan, "Truck, Trailer & Motor Home Manufacturing in the US," IBISWorld Industry Report 33621, July 2018.

dramatically, boosting fuel economy and the range for new hybrids and electric cars.[13] The key point is that these materials solutions are still evolving, with massive repercussions across the mobility space. The region has an extensive metal products and metalworking industry cluster, and Notre Dame has materials-related strengths (which is further noted below); and, while neither is at the center of automotive or vehicular materials R&D, there may be component solutions development capabilities on which to connect.

- **Smart industrial robotics:** The SBE Region, particularly in Elkhart, has embraced industrial automation and robotics as a leader. But, to stay on the leading-edge of increasingly flexible and adaptive production environments, there is a need for similarly flexible and reusable robotic systems that, according to BCC Research, are "perceptive, dexterous, and mobile."[14] These are the evolving "smart" capabilities needed to meet new requirements, where systems are not pre-programmed but rather utilize sensors and adaptive, cognitive programming. What these next-level robotic systems require are faster computation, cognitive technology, as well as enhanced sensor technology to be able to contribute to a range of applications, whereas in the past they were oriented to single applications. These systems ultimately allow for more efficient operations and cost savings for continuous manufacturing processes and the ability to offer mass customization. While industrial robotics are purchased by regional companies from outside the region and robotics are not a recognized strength at regional universities, there may still be opportunities for collaboration between industry and university researchers on specifying needs, testing, and training opportunities.
- **Additive manufacturing:** Three-dimensional (3-D) printing (synonymous with additive) has been in existence for decades, though it is only more recently gaining widespread adoption as costs come down and technologies advance. There are many advantages to 3-D printing, just some of which include speed of production and ability to rapidly prototype; customization and complexity of design; reduced tooling requirements; reduction of waste; production flexibility; reduction of inventory, producing "as needed"; and reduction of weight of parts or components. At the same time, it currently faces limitations with respect to production volumes, limited materials applications, object size, and varying degrees of industry acceptance. Mobility-related industries are utilizing the technology though to varying degrees. Automotive manufacturers are rapid prototyping and producing parts; aerospace companies are developing models, prototyping, and producing replacement parts at lower volumes. As the technology continues to advance, and according to BCC Research, these industries are expected to develop more sophisticated components and applications, such as embedding printed electronics onto parts, advance engine parts (aerospace), and large-scale structures such as aircraft wings and perhaps entire vehicle bodies. Notre Dame has limited capabilities and facilities to leverage in this space, but opportunities to connect with industry should be explored, even if on a facility-usage basis or on initial prototyping projects.

[13] Alan I. Taub, P.E. Krajewski, Alan Luo, and John N. Owens, "The evolution of technology for materials processing over the last 50 years: The automotive example," *Journal of Materials*, February 2007.
[14] Michael Sullivan, *Smart Robotics in Manufacturing: Global Markets to 2022*, BCC Research, May 2018.

Notre Dame has significant and expanding research strength in areas related to these fields:

- **Institute for Flow Physics and Control** represents a unique area of strength for Notre Dame research related to flow diagnostics, prediction, and control leading to basic and now more applied research at the new Turbomachinery Laboratory in propulsion, fluid dynamics, and aerodynamics, particularly with respect to aerospace applications. The Institute can leverage very unique research infrastructure and capabilities, including the largest fluid dynamics lab in the United States with the Hessert Building wind tunnel and the new $40 million Turbomachinery Laboratory that tests gas turbine engines.

- The Institute, while more focused on aerospace applications, has key core competencies related to mobility to leverage, including flow physics applications to RVs and trucks for external aerodynamics as well as advanced instrumentation work at the Turbomachinery Laboratory that represent potential opportunities.

- **The Center for Nano Science and Technology (NDNano)** represents a highly interdisciplinary Center of more than 70 faculty across all science and engineering disciplines, including chemistry, physics, engineering, computer science, and biological sciences, that brings together research strengths of Notre Dame with unique infrastructure, including a clean room and leading-edge tools, equipment, and labs. NDNano research has focused on integrated nano-electronics (next-gen circuits), but also leverages expertise in a broad range of materials, processes, and characterization tools and techniques that could be leveraged for mobility-related advanced materials testing and/or solutions.

Longer-term potential market and technology needs and opportunities:

- **Hybrid-electric or fully electric RVs and trucks:** Hybrid-electric or fully electric RVs and trucks represent a major shift in vehicle technologies. Driven by stricter emissions regulations, falling battery costs, enhanced national charging infrastructure, and increasing consumer interest and acceptance, there is momentum for electrified vehicles (particularly cars) in the near-term.[15] These technologies are being developed in the automotive industry, though there is a role for testing and adaptation work by RV and trucking companies in the long term. While this does not represent a current research strength, the SBE Region could play a role in testing and implementation in RVs and trucks.

- **Autonomous vehicles:** Driverless cars are on the horizon, with McKinsey expecting commercial availability sometime in the next decade and adoption rates anticipated to be up to 15 percent of new car sales that are fully autonomous.[16] In the meantime, advanced driver-assistance systems (ADAS) are being implemented. The SBE Region and its RV and truck manufacturers are not at the forefront in terms of autonomous vehicle development occurring in places like Silicon Valley, Pittsburgh, and Detroit, but could play a role in testing and implementation in RVs and trucks.

  Peripheral applications of artificial intelligence in autonomous vehicles are on the horizon as well in vehicle "platooning" where driverless cars or trucks "talk" to each other, settle into a speed, and drive together in very close proximity. According to the U.S. Department of

[15] McKinsey & Company, "Disruptive trends that will transform the auto industry," January 2016.
[16] Ibid.

Transportation's Volpe Center, a platoon formations approach saves time, boosts lane capacity, and cuts down on congestion, all of which save fuel and money.[17] Automated driving systems enable this and allow vehicles to connect and form a smoothly operating, coordinated "train."

The IT/Data Analytics Opportunity

The IT/data analytics area represents an emerging opportunity for the SBE Region. While neither the industry cluster nor the innovation assets currently represent a large presence in the region, the area does offer potential opportunities to diversify the regional economy in entrepreneurial endeavors as well as through potential connections to, and solutions for, the existing manufacturing base. The opportunity, identified as data analytics and broader IT capabilities, lies within the IT services cluster but transcends industry verticals with a broad array of solutions applicable to nearly all industries. The concept and the "analytics" moniker is used here as a bit of a catch-all, referring to the regional companies engaged in providing the capture, storage, and security and ultimately enabling the analytical and decision-making solutions associated with data and these capabilities. Within the SBE Region, and specifically centered in South Bend, are a cadre of relatively new start-up companies with exciting momentum that are engaged in this platform in varied ways, yet leveraging similar technologies and related competencies (see text box).

Though regional venture-capital investments have been limited overall, more than $15 million in risk capital has flowed to three companies in the data analytics space, reinforcing the promise and potential of these companies (Table 6). In addition to venture capital investments, Simba Chain received an SBIR Phase I award in 2017 to further advance and commercialize its secure messaging blockchain application.

Table 6. Venture Capital Investments in SBE Region IT, Data Analytics–Related Companies, 2010–2017

Company	Venture Capital Deals	Deal Years	Venture Capital Invested ($ in Millions)
Emu Technology	3	2014, 2017	$13.48
Trek10	2	2015, 2016	$0.90
Aunalytics	1	2011	$0.82
Total	**6**		**$15.20**

Source: TEConomy's analysis of PitchBook database.

Data analytics, software, and other IT-related companies are, in general, less likely to patent inventions. That said, both Emu Technology and EmNet have been awarded several patents in recent years (seven between them), indicating an innovative positioning.

The data analytics theme emerging in the SBE Region is rooted in strong demand for the ever-increasing flow and capture of information to help drive business decisions and inform smarter innovations. These trends, as well as major implications for talent needs, are summarized in Figure 7.

[17] https://www.volpe.dot.gov/news/how-automated-car-platoon-works.

An Emerging Cadre of IT/Data Analytics Companies Enable Regional Opportunities

- *Aunalytics* (part of the Data Realty family of companies): Started in 2011 in South Bend, the company was co-founded by a Notre Dame professor, Nitesh Chawla, PhD, and a Notre Dame alumnus, Tracy Graham of Graham Allen Partners. Aunalytics focuses on "big data solutions," helping companies "harness the power of data" via enterprise data management and analytics software and solutions. The company has developed its own end-to-end cloud analytics platform, "Aunsight", and is focused on consumer analytics, digital analytics, operational analytics, and IoT analytics. Its applications serve numerous industry verticals including manufacturing, financial services, retail, healthcare, and others.
- *Data Realty*: The parent company of Aunalytics and MicroIntegration, Data Realty was founded in 2011 to focus not only on data storage and protection, but the "entire data lifecycle," from developing and operating data centers to enabling analytics solutions. The company built its first data center in Ignition Park in South Bend prior to founding Aunalytics to provide the analytics solutions.
- *EmNet*: The company was formed in South Bend in 2004 in a partnership between Notre Dame and the City to provide a real-time decision support system to address the City's combined sewer and rainwater overflow problems. The company combines talent and expertise in control theory, math, civil and environmental engineering, and IT to develop advanced infrastructure analytics, for example, sensors and gates for the sewer system that redirect water during heavy rain to prevent overflow. EmNet's work with the City was a major success, and it has since worked with numerous municipalities around the United States. In early 2018 it was acquired by Xylem, a water technology company. EmNet will remain in South Bend.
- *Emu Technology*: With offices in South Bend and in New York, Emu has among its founders two Notre Dame professors of computer science and engineering. The company is developing "Exascale-capable computing architecture" that is focused on Big Data applications that are "choking today's supercomputers." The company has patented technologies for Big Data analytics and has developed architecture that results in enhanced scale and efficiency and lower energy consumption for pattern matching and analysis with applications for threat intelligence, personalized medicine, fraud detection, and machine learning.
- *MicroIntegration* (part of the Data Realty family of companies): Established in 1999, the company provides IT solutions including servers, security, and network solutions to small/medium business, enterprise, government, and education clients.
- *Trek10*: Founded in 2014 and also based in South Bend, Trek10 focuses on developing cloud-based applications and solutions for clients using Amazon Web Services (AWS) infrastructure. The company focuses on "serverless" computing apps and architectures—where everything is managed for you—and IoT.

In addition, Indiana Technology and Manufacturing Companies (ITAMCO), a company with an extensive history in Plymouth as a "gear shop" metalworking large gears and precision-machining components for mining and other heavy-equipment original equipment manufacturers around the globe, has also developed several leading-edge technology solutions in partnership with researchers at Notre Dame, Georgia Tech, University of Pittsburgh, and others. The company, an early-adopter and implementer of IoT, for example, is passionate about innovation and has developed and spun off multiple companies. These spin-offs have leveraged three federal SBIR grants to help commercialize promising technologies. An example ITAMCO spin-off is Simba Chain.

- Simba Chain represents just the kind of interaction with a regional university that the Line-of-Sight analysis envisions generating. ITAMCO and Notre Dame's Center for Research Computing have collaborated around blockchain technology to develop a "secure, unhackable messaging and transaction platform for the U.S. military." The SBIR grant was awarded through the Defense Advanced Research Projects Agency (DARPA).

In addition, Whirlpool in Benton Harbor is heavily engaged in industrial IoT and launched its "Whirlpool Cloud IoT Infrastructure Platform Project" in 2016 to deploy connected appliances worldwide and ensure a secure technology platform. For the Cloud IoT Project, Whirlpool was recognized with a Digital Edge 50 Award, honoring companies that are leveraging digital technology in an innovative manner.

Figure 7. Overview of Demand for and Integration of Data Analytics and Associated Talent Needs

Exponential Growth of Information Flow	Integration, Push of Analytics into "Legacy" Industries	Demand for Pipelines of Applied Data Analytics Talent
• Increasing ability to collect and store data points and metrics on environmental and behavioral characteristics has generated massive amounts of data • Simultaneous development of relatively "cheap" processing power and data storage has led to accessible analytical computing and big data management software solutions • Key factor driving growth in analytics products and services is ability to intelligently mine these large amounts of data and leverage insights toward actionable industry solutions	• Analytics and supporting IT capabilities have become essential to modern business across non-IT industries and function as underlying enabler of downstream innovation • Demand for analytics solutions by production industries is driven by risk of disruption – already seeing recognition of value and integration into manufacturing, agriculture, logistics, and infrastructure/utilities operating models • Mid-tier service industries in education, finance, and healthcare now experiencing second "wave" of innovation in analytics solutions	• Key enabler of development of innovative solutions for industry is talent base – capital resources required for analytics are relatively cheap • High demand is outpacing supply of talent that works in developing applied solutions in non-tech industries • Regions that have access to talent base and emphasize development of applied knowledge base within specific industry innovation verticals have opportunity to capture large market shares as shifts in business operations continue to occur

Source: TEConomy Partners, LLC.

The momentum of new firms and investments in data analytics and related competencies in the region is both exciting and promising. These firms are generating solutions for companies across numerous industry and market verticals, which holds great promise for the region with the potential to connect, transcend, and impact the regional economy. In particular, as companies pivot toward embracing and implementing disruptive new technologies such as IoT, cloud computing, and Big Data, this emerging area and the ability to meet face-to-face with regional companies and partners offer a potential win-win for the region.

Existing and emerging market and technology opportunities for the region in IT/data analytics related to the mobility and broader advanced manufacturing regional opportunities in process manufacturing include the following:

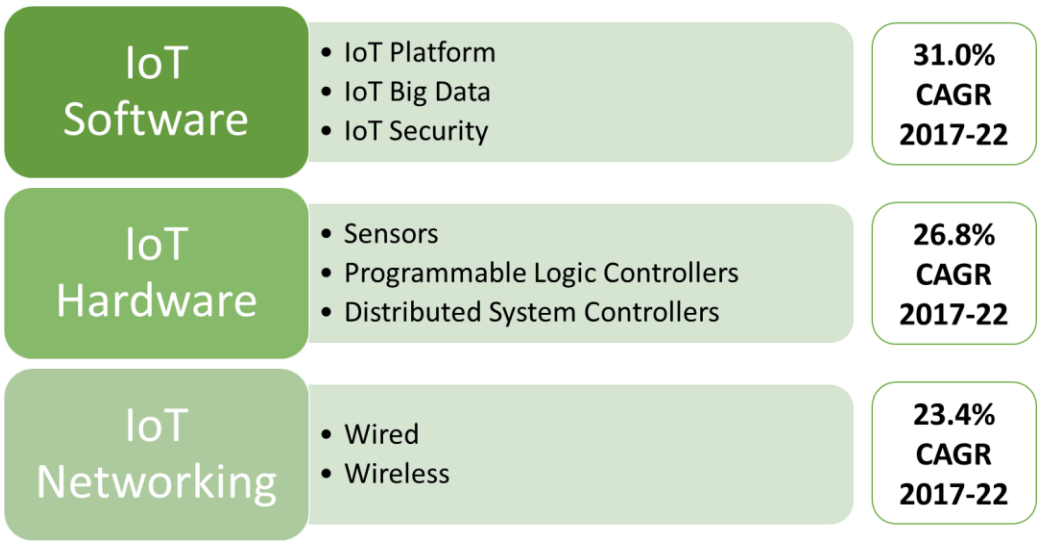
- **Mobility-related software:** With respect to the mobility meta-cluster, software competencies are now a key differentiating factor for industry. Disruptive new technologies in the vehicular space are rooted in software applications, with the shift to car/truck/RV as computer rapidly happening (and underway in boating). Example software-driven technologies include driver-assist and active safety technologies (adaptive cruise control, rain-sensing wipers, and pressure

sensors), connectivity, and infotainment.[18] To be on the forefront of innovative industry change and disruptive technologies, mobility and transportation companies need extensive software capabilities and competencies.

- **IoT for mobility-related and other advanced manufacturers:** Discussions with SBE Regional manufacturers indicate varying interest in university engagement for innovative new commercial technologies or improvements; however, a receptiveness was expressed to overall process improvements and operational efficiencies, including digitizing operations and harnessing the powerful insights of data generation. Manufacturers have historically been limited in their ability to see their operations as a whole, in real time. Data and information were siloed in noncommunicable areas of the operation that led to a whole host of inefficiencies. IoT technology is the game-changer for industrial manufacturing in this capacity, where intelligence can now be shared across an entire interconnected enterprise via "intelligent endpoints dubbed the Internet of Things (IoT)."[19] Intelligent sensors are used throughout the enterprise to communicate in a coordinated manner.

  By implementing IoT, which BCC Research segments into three key, high-growth market areas for manufacturers—software, hardware, and networking (Figure 8)—manufacturers can monitor and manage physical infrastructure, predict repair and maintenance needs, hail workers to the needed areas of the factory floor, and order new parts from suppliers; and, these are just the tip of the iceberg in terms of the diverse applications of IoT. Implementing these systems while operating a major production enterprise is challenging, to say the least. New technologies in cloud computing, data analytics, and cybersecurity are rapidly evolving, however, and are assisting companies implementing IoT.

Figure 8. IoT Manufacturing Technologies by Type and Projected Global Revenues

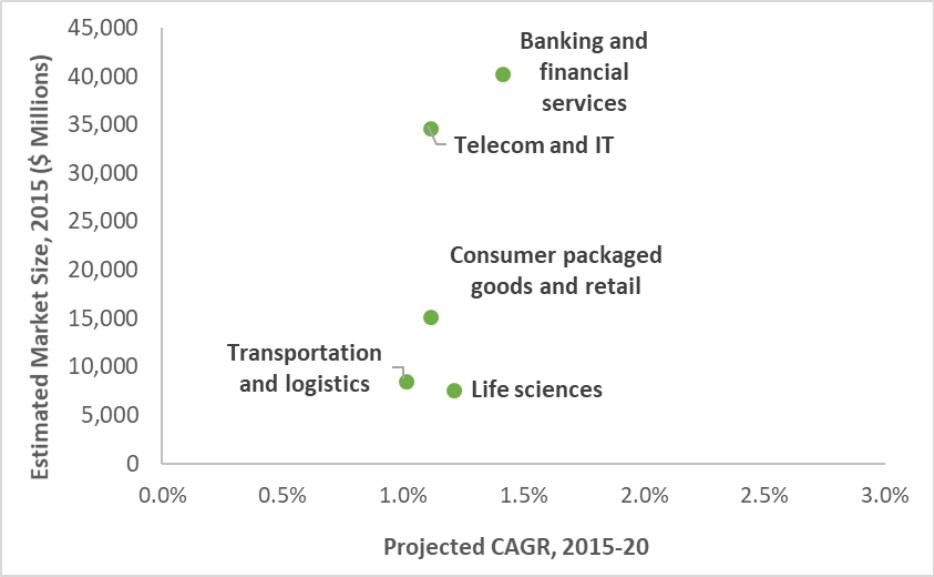


Source: BCC Research. "CAGR" = Compound Annual Growth Rate projected by BCC.

[18] McKinsey & Company, "Disruptive trends that will transform the auto industry," January 2016.
[19] Paul Korzeniowski, *Internet of Things (IoT) Technologies for Process Manufacturing: Global Markets*, BCC Research, February 2018.

- **Data/Advanced analytics** capabilities are allowing companies not only to gain competitive edge in the marketplace regarding consumers and products, but also to optimize operations and costs by helping to forecast and predict key trends and mitigate uncertainties. Advanced analytics requires talent and competencies in statistics, data mining, and visualization, in addition to core IT capabilities for data capture and organization, storage, and a platform for quantitative analysis. Emerging regional strengths are converging across the aforementioned companies and Notre Dame's emphasis and expanding capabilities in a clear line of sight for market opportunities. However, which industry vertical strengths will cluster around regional analytics capabilities associated with this emerging regional competency? This answer is now unknown, but opportunities abound as shown in Figure 9 by the varied end-user industry projections for advanced analytics.

Figure 9. Advanced Analytics Global Market Position and Projected Growth by Industry, 2015–2020



Source: BCC Research. "CAGR" = Compound Annual Growth Rate projected by BCC.

Notre Dame's research enterprise has several potential connection points with industrial innovation within the broadly defined IT/data analytics opportunity area, including the following:

- **The Center for Research Computing (CRC)** was established nearly 10 years ago initially to provide high-performance computing services and support to faculty to support research. Today, that is just a small piece of what the CRC does in its applied work in the following areas:
    - High-Performance Computing (HPC)
    - Cyberinfrastructure Development
    - Research Software Development.

  The differentiator for the CRC is not necessarily the technology infrastructure but rather the team of talented individuals and expansive expertise that brings together multidisciplinary expertise of computational and data scientists, HPC engineers, research programmers—in total about 50 staff and faculty, 20 with PhD's who work side by side with scientists to develop new IT approaches to research. The CRC is widely recognized with key institutional grants and collaborations with NSF, the Department of Energy, DARPA, CERN (or the European Organization

for Nuclear Research), as well as companies such as IBM and local start-ups in Simba Chain (ITAMCO) and Emu.

  - The CRC represents a key regional resource for a range of computing challenges including data analytics for industrial IoT. The Center is eager to work with companies on challenges they face, with the ability to sit side by side with industry in one room/facility on campus and leverage the CRC computing infrastructure for co-development projects/collaborations for end-to-end solutions.

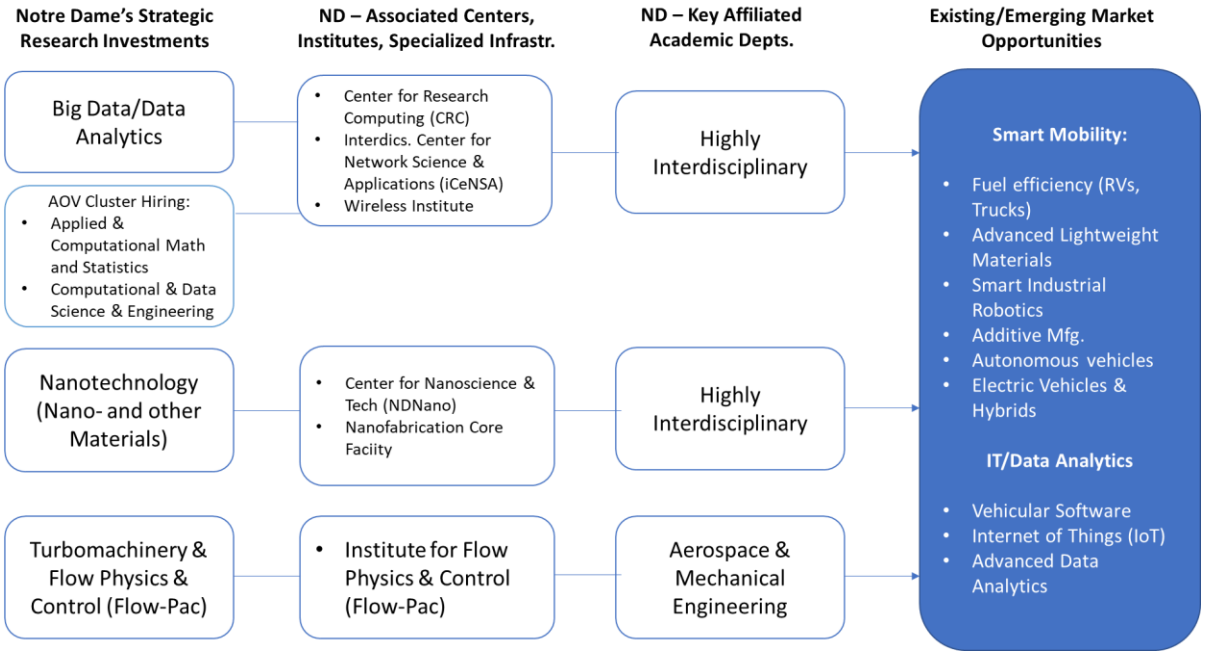
- **Wireless Institute (WI)** within the College of Engineering engages faculty from electrical engineering, computer science and engineering, sociology, law, and finance. The Institute was established to address interdisciplinary problems and has several areas of expertise, including the following:
  - Crowded Spectrum: Dynamic Spectrum Sharing and Distributed Sensing
  - Crowded Devices: Low Power and Low Complexity RF Circuits and RF Coupling
  - Crowded Venues: City-scale and campus-wide testbed
  - Software Defined Radio Communication: algorithms and protocols
  - Network Modeling and Characterization
  - Drone Communications.

  The WI could play a role in sensing applications for IoT as well as potential autonomous vehicle or related applications with respect to connectivity/connected vehicles and infrastructure.

Summary

The potential to develop collaborative connections linking the SBE Region's innovation assets to its industrial strengths and emerging opportunities is significant. Figure 10 summarizes the potential Line of Sight to connect the mobility meta-cluster and the emerging IT/data analytics opportunity area with the research strengths and competencies of Notre Dame.

Figure 10. Line of Sight for Industrial Mobility and IT/Data Analytics–Related Technologies, Market Opportunities to Notre Dame Research Strengths and Competencies



Source: TEConomy Partners, LLC.

The next section lays out a strategic investment plan to ensure robust connections between the region's innovation assets and its existing and emerging industrial base to help ensure long-term economic and community prosperity.

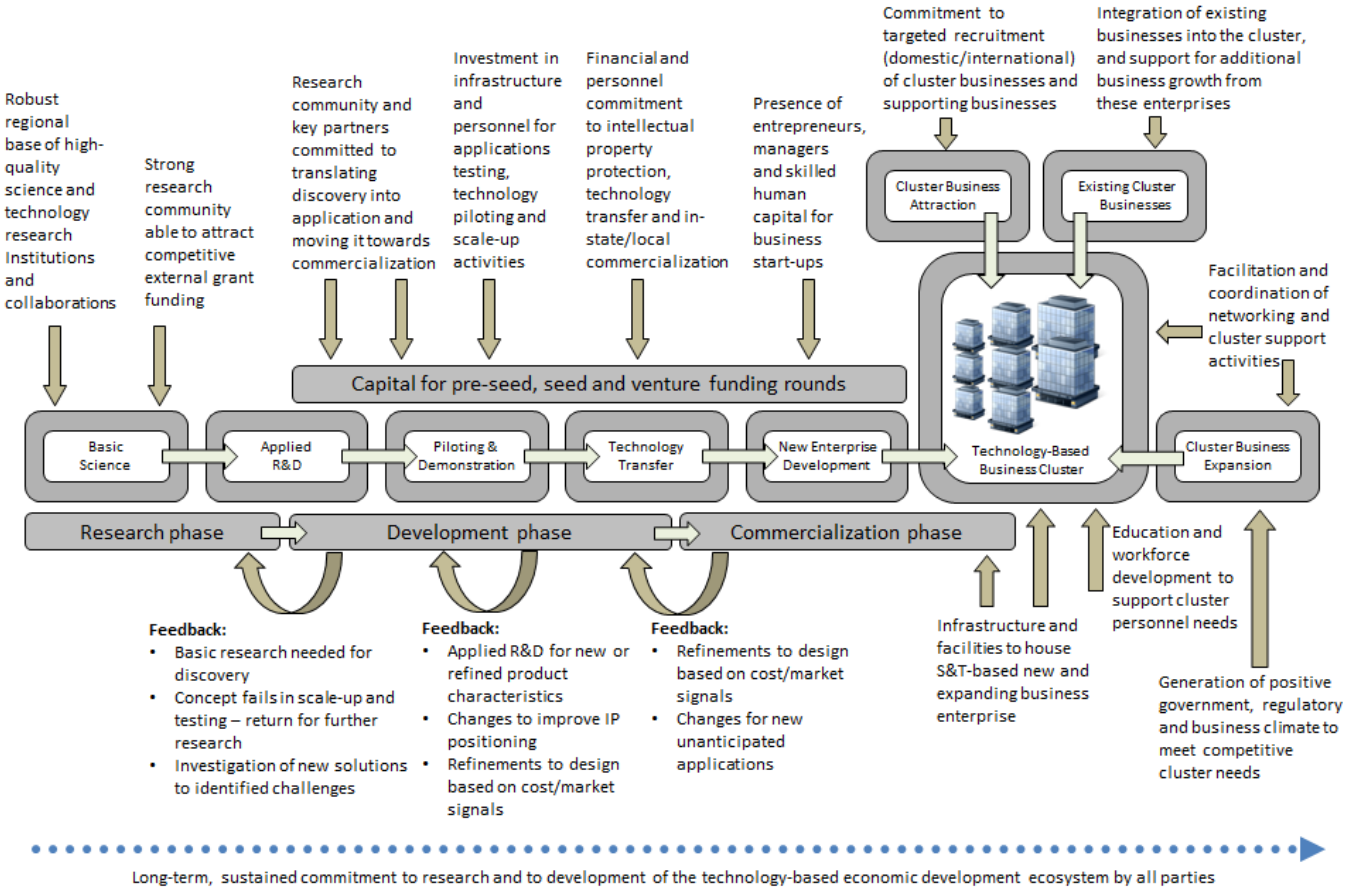
Strategic Recommendations to Position the SBE Region for Long-Term Economic Growth

Drivers of the 21st Century Economy

Economic development in general is not easy to achieve; innovation-based economic development is an even greater challenge. For innovation-based economic development to occur, an entire interconnected sequence of positive economic factors must be in place to strengthen the drivers of, and ecosystem for, advanced industries and traded sectors, namely, innovation, capital, and talent. If any stage of this innovation continuum either inadequately addresses the economic needs or is missing altogether, a sustainable innovation-driven economy able to generate quality jobs is unlikely to develop. To succeed, it takes a high-functioning innovation ecosystem (Figure 11) that is able to do the following:

- Translate R&D activities into new products;
- Move technology commercialization into high-growth businesses; and
- Provide a competitive advantage in which emerging firms develop and stay, existing businesses grow, and out-of-state businesses are attracted.

Figure 11. A Robust Innovation-Based Economic Development Ecosystem



Source: TEConomy Partners, LLC.

A region must be willing to support collaborations between private and public sectors, serving as facilitator and catalyst to be able to develop an impactful innovation continuum. Its economic development policies must be sensitive to, and targeted at, advanced industries in new and different ways. Economic experts argue that, to compete in the future, a region must have an economic base composed of firms that do the following:

- Constantly innovate based on knowledge;
- Maintain their competitiveness by focusing on innovation, time to market, quality, and cost;
- Integrate the technological revolutions into the workplace, both in terms of how they do business and in terms of the businesses and markets in which they choose to participate;
- Network with other firms and institutions, establishing alliances by collaborating; and
- Reward and invest in their primary resources: talented individuals and teams.

The SBE Region has a critical role to play in ensuring that its innovation ecosystem is structured to leverage disruptive change and adapt to it. To accelerate the region's economy, it is proposed that the SBE Regional Partnership focus its efforts on three strategic priorities. The emphasis should be on leveraging and complementing existing efforts while catalyzing long-term economic growth across the region. Specifically, the three strategies should focus on the following:

- Infusing cutting-edge innovation into the region's industrial economic drivers to ensure that existing industries remain globally competitive;
- Catalyzing the entrepreneurial ecosystem to diversify the economy and drive future economic growth; and
- Developing, retaining, and attracting the talent that the region's industry demands.

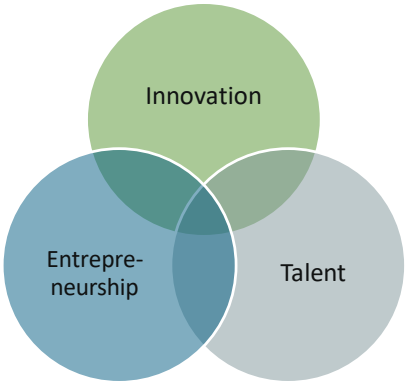


Table 7 provides a summary of the recommended strategic plan to position the SBE Region for long-term economic growth and prosperity.

Table 7. Recommended Strategies and Actions to Position the SBE Region for Long-Term Economic Growth

Strategy	Targeted Actions to Pursue
Strategy One **Foster the Infusion of Advanced Innovation Processes, Products, and Techniques into the SBE Region's Advanced Manufacturing Industries, Starting with the Mobility Meta-Cluster and its Supply Chain**	**Action 1:** Create an Institute for Industry Innovation, in partnership with regional industrial leaders, University of Notre Dame, Purdue, and other regional institutions of higher education, that focuses on infusing advanced innovation processes, products, and techniques into the SBE Region's industrial base.
Strategy Two **Catalyze the Entrepreneurial Ecosystem to Diversify the Economy and Drive Future Economic Growth**	**Action 2:** Expand the role of the SBE Regional Partnership to provide entrepreneurial support services to innovative start-up companies and coordinate with other entrepreneurial initiatives in the region.
	Action 3: Create an indigenous pipeline of risk capital funds to invest in entrepreneurial efforts in the region.
Strategy Three **Develop, Retain, and Attract the Talent that the SBE Region's Existing and Emerging Industries Demand**	**Action 4:** Create and scale experiential learning opportunities to connect students with industry as well as retrain incumbent workers.
	Action 5: Launch a marketing/branding campaign to attract alumni back to the SBE Region by creating an Alumni Recruitment Program.

Strategy One: Foster the Infusion of Advanced Innovation Processes, Products, and Techniques into the SBE Region's Advanced Manufacturing Industries, Starting with the Mobility Meta-Cluster and its Supply Chain

Rationale

The rate of technological advancement in today's global marketplace does not allow for companies to remain static—those that remain so will quickly become obsolete. Today's markets demand new, better, faster, and cheaper products and processes; and companies are leapfrogging one another in a constant race to innovate, secure market share, and capture new market spaces. In this environment, successful companies will do one of the following three:

1. Embrace change and accept the risks that exist at the leading edge of innovation (early adopters);
2. Be nimble to adapt to innovations as they become mainstream (followers); or
3. Go out of business (laggards).

It is important to note that innovation is being driven more and more by technological convergence. The phenomenon of technological convergence is not new. Many products contain multiple components that have had unique development pathways prior to converging into a novel product (for example, global positioning system, mobile telephony, photography, and mobile Internet connectivity converging

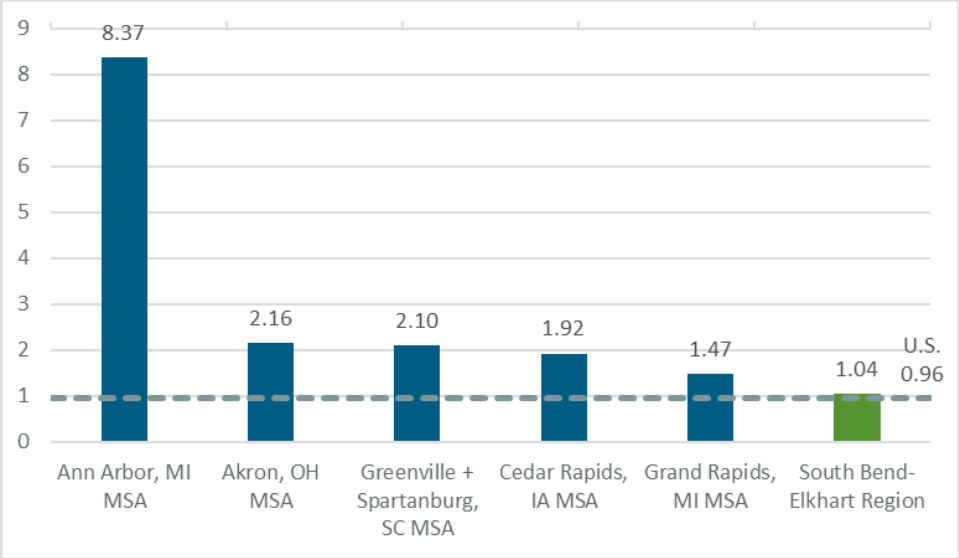
into a smart phone). A more current phenomenon, however, is the large-scale convergence that brings together distinct industry sectors, which historically have operated largely independent of one another, that today are starting to coalesce around areas of mutual interest. In this new paradigm, technologies and companies from one sector converge with those from another (or several others) to provide a combined solution to market needs and opportunities. An example is the growing field of autonomous mobility services that is being advanced through collaboration between automotive companies, alternative forms of power and propulsion sources, automation/sensors technology pioneers, and data analytics.

The ability of any region to remain economically viable is correlated to its industries' ability to adopt advanced innovation processes, products, and techniques into their daily operations.

The SBE Region's Current Situation

As the previous section stressed, the ability of SBE companies to develop new innovative products and employ innovative processes into their business models will be critical to the region's ability to grow and prosper economically. However, when patent activity is examined, the SBE Region is not performing well compared with the benchmark regions. And, while the SBE Region just exceeds national average patent levels relative to the size of its economy (Figure 12), as noted in the previous section, much of the innovation activity is concentrated at Notre Dame and private sector companies outside of the mobility meta-cluster. So, despite the high concentration and breadth of mobility-related economic strengths, from an innovation perspective, the region has limited IP generation.

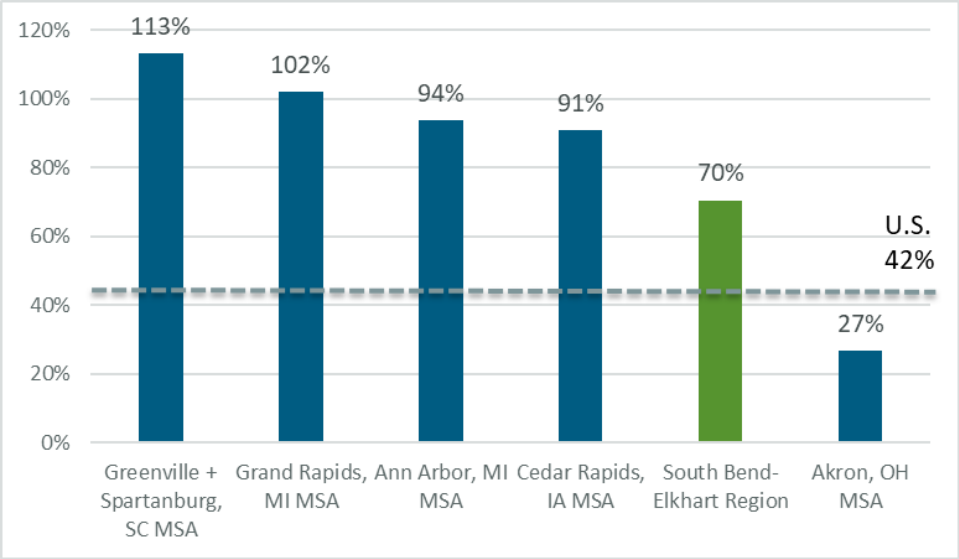
Figure 12. Patent Awards for SBE Region, Benchmarks, and the United States, per $100 Million GDP, 2017



Source: TEConomy's analysis of data from Clarivate Analytics's Derwent Innovation patent database.

When considering growth in patent awards, the SBE Region has increased its levels since 2010, but has lagged four of five benchmark regions (Figure 13).

Figure 13. Growth in Patent Awards for SBE Region, Benchmarks, and the United States, 2010–2017



Source: TEConomy's analysis of data from Clarivate Analytics's Derwent Innovation patent database.

Interview discussions with regional companies revealed a mixed reception to embracing opportunities to connect with local universities on innovation enhancements. This may reflect skepticism on the part of companies that university researchers are either equipped, able, or interested in working with them on innovation or a perceived mismatch in capabilities. But, when considered along with discussions of their workforce as a "commodity" (rather than as a key asset to leverage), the relatively weak innovation activity levels, lack of emerging new high-growth potential companies as evidenced by lagging levels of venture capital and federal commercialization funding, and lower levels of STEM-related talent, this limited interest in innovation partnering is a concern.

To help drive improvement in these innovation metrics, the SBE Region must focus its investments on infusing cutting-edge innovation into the region's industrial economic drivers to ensure that existing industries remain globally competitive and new industries emerge. The following recommendation seeks to advance that goal.

Action 1: Create an Institute for Industry Innovation, in partnership with regional industrial leaders, University of Notre Dame, Purdue, and other regional institutions of higher education, that focuses on infusing advanced innovation processes, products, and techniques into the SBE Region's industrial base.

A fundamental shift is happening throughout the global mobility industry cluster as new automation, data collection, and materials technologies are being increasingly incorporated into traditional assembly and processing operations. Next-generation manufacturing and materials represents the broad portfolio of technologies that are expected to revolutionize the way that products are made, ranging from incorporation of more advanced raw materials inputs to analytics-driven predictions of useful life for downstream finished parts and systems.

The technology platforms that make up next-generation manufacturing and materials are aligned with advancing and consolidating the traditional steps of the manufacturing process and include the following:

- Digital product design and modeling, which allows manufacturers to design and test in virtual environments with both the manufacturing process and use life of products in mind.
- Novel advanced materials with highly customizable properties and highly precise means of being shaped into parts and components while maintaining durability and consistency.
- New manufacturing processes that replace traditional subtractive manufacturing, revolving primarily around the scaling of technologies in additive manufacturing and 3-D printing.
- Industrial automation and robotics systems that perform increasingly complicated fabrication and assembly tasks.
- Embedded sensor and instrument networks within production systems and machinery that collect and report data in real time to help diagnose and dynamically react to problems as well as build out large-scale analytics tools for manufacturing operations.
- Postprocessing and finishing technologies that rely on combinations of novel finishing materials such as coatings and polymers, sensing and materials analysis, and automation to ensure consistency and quality in products across varying production run sizes.

Taken together as a whole, the convergence of these technology platforms within modern manufacturing operations will lead to a more wholly integrated "smart manufacturing" environment, with information from all stages of the production process interacting and creating feedback loops that allow a production line to "tune" itself without any stoppages or retooling requirements. These smart production environments also represent a new vision for the role of manufacturing in supporting the mobility industry, where just-in-time orders and highly variable production run sizes can be efficiently delivered at increasingly local scales to customers of all sizes. Leaders in adopting innovations in this space can expect to gain significant advantages over competitors in terms of producing value-added products and reducing operating costs.

As discussed previously, the SBE Region has a unique strength in the mobility cluster when both its primary industry drivers and diverse supply chain are taken into account. In addition, the region has a growing base of academic R&D strengths in areas that relate to this meta-cluster. However, at the present time, few companies report working collaboratively with academic researchers. In fact, a number of the interviewees suggested that they are unaware of the research being conducted within the academic institutions and do not believe it is relevant to their operations.

To overcome this problem, the region, in partnership with institutions of higher education and industrial leaders, should create an Institute for Industry Innovation that focuses on infusing advanced innovation processes, products, and techniques into the daily operations of the SBE Region's industrial base. The Institute should focus on cross-disciplinary areas of technology convergence working to ensure that the innovation needs of existing regional industry are met, new opportunities to diversify the economy emerge, and talent is generated and linked to regional economic drivers.

The core activities of the Institute would include four specific nodes/functions:

Node 1—Public-Private-Academic Applied Development Projects: Through the creation of the Institute for Industry Innovation, Notre Dame, in partnership with other regional institutions of higher education, would work to assist the region's existing manufacturers in using, applying, and developing technologies to improve their products and processes. The Institute would address strategic priorities within the mobility sector and its supply chain, as well as address the needs of new and emerging industries as they develop in the future. Investments would be made in design labs, pilot plants, and demonstration facilities built around specialized knowledge and expertise in key areas of mobility, including next-generation manufacturing, advanced materials, and sensors/controls/instrumentation. The Institute would offer pilot-plant and product production and applications support to industry in the region, as well as support in product design and development.

Key services and focus areas for the Institute for Industry Innovation would include the following:

- Product development and design services, including serving as a design group, creating concepts, developing preliminary designs, fabricating and testing prototypes, documenting designs, and identifying manufacturing resources and alternatives.
- Sophisticated design analysis tools to increase product reliability, reduce warranty costs, and enhance customer satisfaction.
- Development of new product ideas by brainstorming and serving as engineers and designers.

Oregon Nanoscience and Microtechnologies Institute

The Oregon Nanoscience and Microtechnologies Institute (ONAMI) is an example of a public-private partnership that was seeded with state dollars. ONAMI is a collaboration of four Oregon's universities (Oregon Health and Science University, University of Oregon, Oregon State University (OSU), and Portland State University), a national laboratory (Pacific Northwest National Laboratory [PNNL]), industry, and the investment community. It is one of three "Signature Research Centers" created by the State of Oregon. ONAMI's mission is to accelerate research and commercialization of materials science and related device and system technology in Oregon.

ONAMI seeks to achieve its mission by doing the following:

- Providing matching funds for federal and private collaborative research projects undertaken by ONAMI principal investigators.
- Providing industry with access to a collection of university-based shared/open user facilities on a user-friendly, fee-for-service basis. These are world-class materials characterization and fabrication laboratories. Not only do the firms have access to sophisticated equipment, but they also have access to people with the expertise to run the equipment.
- Providing commercialization funding and business development services. ONAMI provides proof-of-concept grants that enable university researchers to conduct commercialization activities and helps link entrepreneurs to sources of private capital.
- Holding periodic conferences and seminars and providing opportunities for networking among industry and academic researchers. The ONAMI network includes 150 research affiliates at four universities and PNNL.
- Connecting students with industry through meaningful projects/internships.

However, employing an "if we build it, they will come" mentality will not lead to success. Significant effort to forge relationships and build connections between the region's industrial base and university assets will need to be undertaken. The cornerstone of the recommended action is having "translators" to sustain the industry partnership effort. Viewed as a function/role of the Institute for Industry Innovation, translators would be the industry-facing representative of Note Dame and other regional research universities across areas related to mobility and advanced manufacturing.

These translators will need to offer a high-touch service function that is highly responsive to both industry and faculty clients to drive engagement and act as a connective "bridge" that will lead to sponsored research activities and sustained long-term relationships with companies.

The specific roles of the translators will be to conduct proactive outreach to industry through company site visits as well as offering technology symposiums and regular workshops with industry groups, helping to coordinate industry requests for research collaborations that come out of these efforts, and building relationships with faculty and research centers seeking to grow in industry research collaborations and offering industry access to shared-use labs.

It is critical that these translators be experienced industry executives with scientific expertise, who have worked with universities while in industry and possess know-how in business development. These translators need to be viewed as strategic, outward-facing resources and so need to have a line of reporting to each university's lead for research administration.

Translators at the Consortia for Improving Medicine with Innovation and Technology

A successful collaborative initiative that has broadly embraced the use of translators, also referred to as site miners, is the Consortia for Improving Medicine with Innovation and Technology (CIMIT), a clinically based consortia of Boston-area hospitals and engineering schools that supports translational research by multidisciplinary teams for medical device and clinical technology applications. CIMIT involves physicians from Harvard teaching hospitals who collaborate with scientists and engineers from the Massachusetts Institute of Technology, Charles Stark Draper Labs, Northeastern University, and Boston University, as well as a wide range of industry partners.

CIMIT demonstrates that it is possible to systematically facilitate the process of addressing real market opportunities through innovative technology solutions. It engages with clinicians and industry to define key areas of focus.

Of CIMIT's facilitation roles, that of a site miner is the most unusual, inventive, and productive. Site miners have proven to be the key to penetrating the multiple isolated member institutions and to connecting people and ideas across the cultural walls of these institutions and even across the boundaries separating departments within them. They literally "mine" the institutions for projects and people deserving CIMIT's attention and help.

Site miners, or translators, at academic and research institutions open and maintain dialogues with the clinicians and researchers at the front lines of healthcare and technology within their institutions. Site miners at companies and foundations look for strategic opportunities for their organizations to engage and help address an important business opportunity or organizational mission. Site miners across the consortia work with each other.

Key to success of each translator is the ability to assess the industry requests and offer a value-added service of matching to specific faculty and to other university resources with the expertise to address the needs of the company. Being university-wide will enable unbiased outreach to all faculty that can meet specific industry needs.

Node 2—Operational Assistance in Identifying Areas of Improvement, Streamlining Processes, and Ultimately Increasing Competitiveness: Across the nation, the National Institute of Standards and Technology (NIST) has advanced a network of manufacturing modernization programs through its Manufacturing Extension Partnership (MEP), which require state and industry matching funds. Since its establishment of a national network of MEP centers in the mid-1990s, much of the emphasis of this program has been on initiatives to reduce the cost of manufacturing in the United States through the application of quality and continuous improvement programs such as lean manufacturing and ISO 9000 standards. The expectation has been that, as a manufacturer reduces its cost of making and delivering a product, while reducing delivery and cycle times, it should be able to attract new business.

The NIST MEP program provides resources and a system for reaching out to small- and medium-sized manufacturers through experienced field staff. Purdue delivers Indiana's MEP program statewide. In speaking with industry, the program was highly regarded; but, individuals recognized that its ability to provide services to regional industry was constrained by the resources available through the statewide initiative. In addition, industrial leaders noted that many of the small- and medium-sized manufacturers and supply-chain partners that comprise the mobility meta-cluster are constrained in their ability to adopt innovation due to operational issues that hindered the companies' bottom line. By having the Institute for Industry Innovation focus not only on applied development projects but also on operational efficiencies, the Institute will be able to serve the needs of a broader base of companies.

It is recommended that, as a component of Institute's activities, the Purdue MEP system be leveraged by providing additional resources to increase consulting capacity in the region so that more companies can receive operational assistance. Services would include the following:

- Lean manufacturing assessment and implementation
- Market research to identify customers wants, market trends, and product options
- Supply-chain development, including matching customers with suppliers and vendors
- Sustainability and energy-efficiency assessment and assistance
- Quality improvement and quality systems assessments and assistance
- Leadership development and training.

It should be noted that as companies are able to increase their bottom-line profitability through operational efficiencies, they will be in a better position to identify areas of innovation and development that could increase top line business growth and become involved in applied development projects with the Institute.

Node 3—Commercialization of Innovation through Entrepreneurial Endeavors: While many of the projects envisioned under Nodes 1 and 2 will be with existing industry, it is also a goal of the Institute for Industry Innovation to pursue the commercialization of new products and processes that are generated from the applied research that is undertaken. Therefore, it will be critical that the entrepreneurial

efforts being recommended under Strategy Two support the opportunities that will result from this effort (see Strategy Two Action 2 for additional information).

Node 4—Placement of Talent into Regional Firms to Help Meet Industrial Innovation Needs: The ability to retain the region's brightest talent being generated from its institutions of higher education is critical to developing the workforce required in the 21st century economy. It has long been recognized that a key missing element of long-term economic growth in the region is its inability to retain the talent being generated at a scale that can alter the region's economic trajectory. Therefore, a key component of the Institute for Industry Innovation must be to link students with regional companies so that they can gain an appreciation of the exciting career opportunities that are available in the region. Strategy Three Action 4 addresses this need.

Strategy Two: Catalyze the Entrepreneurial Ecosystem to Diversify the Economy and Drive Future Economic Growth

Rationale

Key to diversifying the economy of a region are the entrepreneurs who can turn innovation into successful businesses. Innovation, in and of itself, will not necessarily translate into economic activity. Rather, it is the application of a technology and its introduction into the marketplace that result in economic growth.

The role of entrepreneurs in stimulating economic growth is not a 21st century phenomenon, but instead was understood as an economic reality at the turn of the last century. The development of assembly-line production, for example, and its application to the mass production of automobiles reduced the time that entrepreneur Henry Ford took to produce the Model T Ford by 68 percent over 6 years and reduced its cost by 62 percent, allowing middle-class families to afford what had once been a luxury. During the past century, innovation in mechanics, computing technology, medicine, and business practices has driven economic growth, raised wages, and helped Americans lead longer and healthier lives.

What characterizes an entrepreneurial firm? The National Governors' Association puts forth this definition of entrepreneurship and entrepreneurs:

> *Entrepreneurship is the ability to amass the necessary resources to capitalize on new business opportunities; and an entrepreneur is one who combines smart business practices with innovation, without regard for resources under his or her control.*[20]

[20] National Governors' Association, *Governor's Guide to Strengthening State Entrepreneurship Policy*, 1999.

It is important to note that, while most entrepreneurs start by forming small businesses, not all small businesses are entrepreneurial. The needs of small businesses and entrepreneurs may be similar at first during the start-up phase, but they quickly diverge. Small business owners create companies to generate wealth and provide employment and income for themselves and others; entrepreneurs are interested in creating new innovative products or services that lead to further investment and growth. Most small businesses serve a local or regional market, whereas entrepreneurial companies often are focused on the national and global marketplace. It is also important to remember that entrepreneurship includes more than just start-ups. Mature firms must be entrepreneurial in developing new products and entering new markets.

Entrepreneurs

- Advance innovative ideas that serve unmet market needs into new high-growth potential companies
- Focus on traded sectors serving the national and global marketplace
- Create dynamic and flexible new industries and firms to replace those that are no longer viable in a rapidly changing global economy
- Provide most new employment opportunities, especially in high-paying jobs
- Create wealth that is reinvested in new enterprises and, through demonstrated philanthropic activity, in communities.

The Decline of Entrepreneurship—A National Dilemma

Entrepreneurship, the economic force that is widely understood to have made this country the envy of the world, is in a state of decline. Many different studies over the past several years, using different ways to measure the growth and success of start-ups, all point to the same conclusion— the decline in U.S. entrepreneurship is impeding economic growth.

- A study by the National Bureau of Economic Research (NBER) shows that start-up activity has been slowing down in the United States for about three decades, dropping sharply over the past 10 years. New firms accounted for about 13 percent of all companies in the late 1980s, but only about 8 percent two decades later. In the 1980s and 1990s, the small number of young, innovative, and dynamic companies grew at very high rates. But, in the post-2000 period, start-ups contributed less to U.S. job creation than they did in earlier decades.[21]
- The Kauffman Foundation reports that the percentage of adults owning a business has been declining since the 1990s, when the foundation first began to track that number.[22]
- A study by the Brookings Institution found that the start-up rate (the number of new companies as a percentage of all firms) has fallen by nearly half since 1978.[23]

The impact of this decline cannot be overstated. A report prepared for the Small Business Administration's Office of Advocacy comparing regions with strong and weak entrepreneurial activity found that the most entrepreneurial regions experienced greater economic prosperity compared with

[21] Ryan A. Decker, John Haltiwanger, Ron S. Jarmin, and Javier Miranda, "Where Has All the Skewness Gone? The Decline in High-Growth (Young) Firms in the U.S.," NBER Working Paper No. 21776, January 2016.
[22] The Ewing Marion Kauffman Foundation, *The Kauffman Index: Main Street Entrepreneurship,* December 2015.
[23] The Brookings Institution, *What's Driving the Decline in the Firm Formation Rate? A Partial Explanation,* November 2014.

the least entrepreneurial regions. "They had 125 percent higher employment growth, 58 percent higher wage growth and 109 percent higher productivity."[24] As a result, states and regions that recognize the benefits of entrepreneurship and the role it plays in today's knowledge-based economy are developing policies and programs to establish an environment that creates, attracts, and retains entrepreneurs, and an infrastructure to support them.

However, with a few notable exceptions such as Boston and Silicon Valley, the entrepreneurial climate necessary to generate high-growth enterprises has not developed fully and sustainably through market forces alone. Building a critical mass of entrepreneurial management talent and risk capital in a locality depends on providing the resources that must be amassed and the services needed to successfully build a company.

As a result, catalyzing entrepreneurial activity is a challenge for many regions. It is often stated that entrepreneurship is a "contact sport," and the barriers and obstacles to being able to scale a firm is significant, particularly highly innovative firms. The areas that innovative entrepreneurs indicate are their greatest obstacles are access to experienced managerial talent, risk capital, and sales. Of these, the most significant obstacle to creating and growing entrepreneurial companies is the lack of experienced management talent. For the SBE Region, there simply is a lack of experienced, serial entrepreneurs who know how to turn an idea or a product into a successful venture. Such serial entrepreneurs are needed not only to lead new ventures but also to serve as mentors to help fledgling entrepreneurs develop their skills and increase their chances of success. Serial entrepreneurs have contacts in the investor community, can recognize quality deals, and help to generate deal flow that helps firms access capital markets.

The second challenge facing entrepreneurs is the lack of available risk capital. Entrepreneurs must have access to sufficient capital to finance business growth. However, in many regions, few sources of funding bridge the gap between the points at which (1) a discovery has been identified and demonstrated and (2) a business case has been validated and venture or other debt capital can be obtained. It is also difficult to obtain seed and early-stage investment because venture funds, as they have become larger, tend to make larger, later-stage investments. As a result, angel investors have also moved downstream (further away from pre-seed and seed investments), making more post-seed and later-stage investments than previously.

The third challenge that entrepreneurs face is the ability to find customers and markets. Entrepreneurial assistance programs usually focus primarily on providing financial help, business planning, and physical space to start-up companies to increase their chance of survival. And, indeed, start-up companies face many obstacles. But, just because a start-up company remains in existence doesn't mean that success has been achieved. For many of these companies, the real challenges come when they are ready to grow. Once they have a management team and an organization in place, have obtained investment capital, and are ready to move to the next level, fewer resources are available to assist these companies in finding customers, identifying new markets, and generally increasing sales—all factors that will determine the level of their contribution to the economic health of the communities in which they reside. In addition, firms have difficulty keeping up with the competition, being aware of new

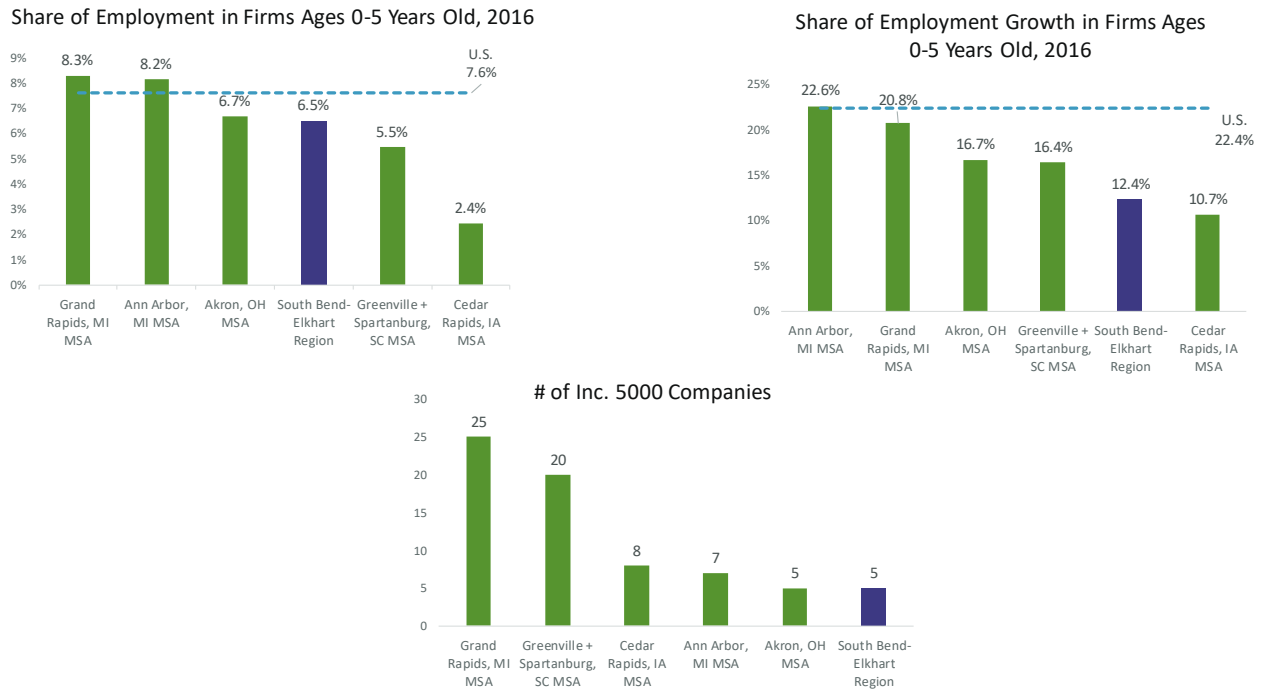
[24] *The Innovation-Entrepreneurship NEXUS: A National Assessment of Entrepreneurship and Regional Economic Growth and Development*. Powell, Ohio: Advanced Research Technologies, LLC, April 2005.

discoveries that may affect their markets, and supporting continued product development, obstacles that can be lessened through closer interactions with universities and their researchers.

The SBE Region's Current Situation

When the SBE Region's rate of entrepreneurial churn is compared with the benchmark regions and the nation, it is discovered that the SBE Region ranks very low in its share of employment in "young" firms (those ages 0 to 5 years) as well as growth rate, behind U.S. levels in both measures (Figure 14). In addition, among the benchmark regions, SBE ranks last in presence of firms on the Inc. 5000 list of fastest-growing companies.

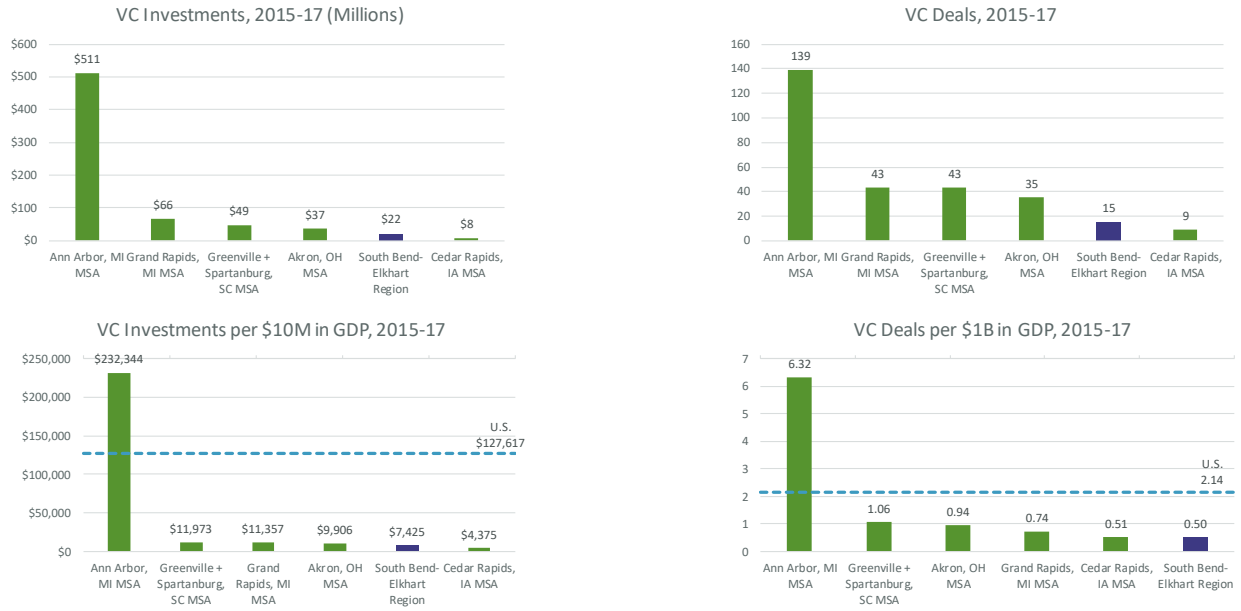
Figure 14. The SBE Region's Entrepreneurial Churn



Sources: TEConomy's of U.S. Census Bureau, Quarterly Workforce Indicators data.
Inc. 5000 Website (www.inc.com/inc5000).

A further concern is raised regarding the SBE Region's ability to scale innovative entrepreneurial firms when the level of risk capital deployed across the region is examined. As illustrated in Figure 15, the SBE Region lags behind the United States and the benchmark regions.

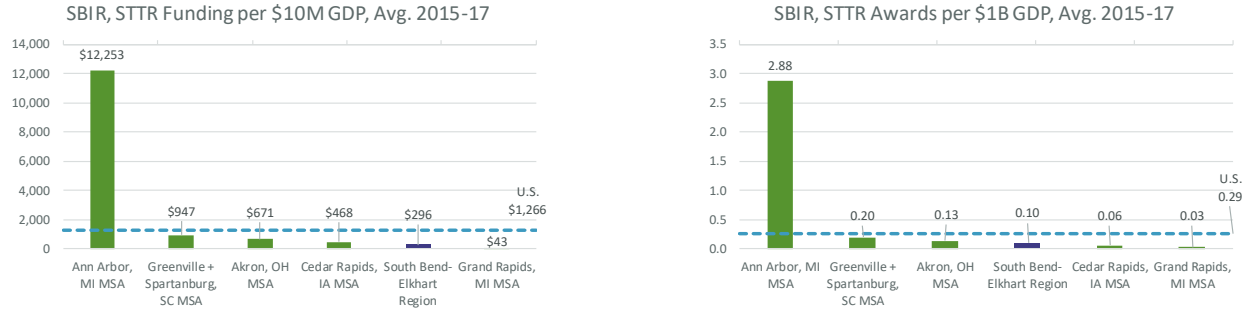
Figure 15. Level of Risk Capital Investments



Source: TEConomy's analysis of PitchBook venture investment database.

Finally, when the federal SBIR/STTR awards are analyzed (a source of non-dilutive financing), the region does not fare much better (Figure 16).

Figure 16. SBIR/STTR Funding Levels



Source: TEConomy's analysis of the federal SBIR/STTR grant database.

While the data paint a rather bleak picture, there is reason to believe that the level of entrepreneurial dynamism in the region is changing, and at a rather quick pace, based on recent efforts/initiatives, and that the recommendations in this report will further reverse the challenges. Through Notre Dame's investment in the IDEA Center (Innovation, De-Risking and Enterprise Acceleration), there is now a concentrated effort to provide the necessary space, services, and expertise for idea development, commercialization, business formation, prototyping, entrepreneurial education, and student entrepreneurial efforts. It is designed to bring the best Notre Dame faculty, staff, and student ideas and innovations to market. Since its creation in 2017, the IDEA Center has focused on developing teams around innovative ideas to raise the first round of professional investment for a new start-up or for the technology to be licensed to an established company. The process is focused on "de-risking" technologies. Services are available for faculty, staff, and students, and through a partnership with the

SBE Regional Partnership is now open to community-vetted opportunities. There are also plans to open the process to Notre Dame alumni this fall. In its first year of operations, the Center started 27 companies that raised $4 million in funding. The IDEA Center is on pace to evaluate 300 inventions this year with the goal of 30 start-ups per year. In addition, the IDEA Center is raising risk capital funds to support these entrepreneurial efforts.[25]

To capitalize upon this recently formed commercialization engine, it will be critical that the SBE Region develop an entrepreneurial ecosystem that is supportive of these emerging firms so that they can grow and scale within the region instead of leaving to find resources/entrepreneurial capacity elsewhere. The following recommendations seek to catalyze the SBE Region's entrepreneurial ecosystem to help diversify the economy and drive future economic growth.

Action 2: Expand the role of the SBE Regional Partnership to provide entrepreneurial support services to innovative start-up companies and coordinate with other entrepreneurial initiatives in the region.

It is recommended that the region build upon the existing momentum being created by Notre Dame's IDEA Center and the work of the SBE Regional Partnership's Entrepreneurship Committee (Startup South Bend-Elkhart) by funding an initiative to provide dedicated, value-added business assistance to the region's most promising entrepreneurial endeavors. This work would leverage the efforts being undertaken currently within the Elevate Ventures Partnership, which focuses on providing entrepreneurial educational content/events/seminars and support for community-based entrepreneurial organizations, programs, and initiatives. It is recommended that the role of the SBE Regional Partnership be expanded to provide entrepreneurial support services to ensure consistent, significant, value-added assistance to high-growth potential companies that are fundable but lack the C-level talent, or management team, to help scale the company. An Entrepreneurs-in-Residence (EIR) program is a concept that many entrepreneurial assistance organizations have adopted over the last decade, to fulfill this function. Under a typical arrangement, companies that become part of an organization's portfolio are assigned the services of an Entrepreneur-in-Residence. The EIR team consists of highly experienced entrepreneurs who have been involved in the successful creation of innovation-based start-up companies and early-stage venture deals. Each portfolio company receives a significant level of value-added commercialization and access to markets and customer expertise from their assigned EIR, who plays an operating role in the company. Elevate Ventures, in partnership with the region, is currently providing funding for a part-time EIR within the region. However, this position includes numerous other outreach and coordinating efforts. To increase deal flow in the region and capture ideas coming out of the IDEA Center, it will be critical to have additional capacity in place.

It is recommended that the initiative be created by formalizing the efforts of Startup South Bend-Elkhart by expanding the role of the SBE Regional Partnership to undertake the delivery of these additional services. The Partnership's primary added responsibility would be to recruit the expertise of EIRs to bolster the executive talent pool within the region with the expectation that the EIRs would eventually

[25] See: https://www.xconomy.com/indiana/2018/08/01/startup-jesus-notre-dame-launched-a-record-27-new-companies-in-2017/

transition to full-time employee status within one of his/her portfolio companies. It is envisioned that Notre Dame's alumni network would be a prime pool upon which to identify potential EIR candidates (see further discussion in Strategy Three Action 5).

Overall, the EIR Program would provide the following value-added services to the most promising start-up companies:

- Assistance with forming a business team of managers to assist with market research, technical evaluations, regulatory issues, etc.
- In-depth counseling and advice to prepare the entrepreneur to present investment-grade plans to investors.
- Organizational documentation, preliminary technology and market assessments, and start-up strategic planning.
- Linking companies to sources of capital and helping them prepare to seek venture financing.
- Providing the requisite subject matter expertise in key domain areas of greatest opportunity in the SBE Region. It is recommended that the first EIRs be hired with subject matter expertise in the areas of:
    - Manufacturing 4.0 innovations
    - IT/Data Analytics.

The SBE Regional Partnership would also be tasked with serving as a regional coordinator of other entrepreneurial services available within the region as well as coordinating the appropriate development of physical space to house the growing companies over time as the number of start-ups significantly increases, including the build-out of the Renaissance District and exploring the possibility of a facility/node in Goshen given the entrepreneurial focus and activity within that community.

If implemented, this comprehensive suite of value-added business assistance services, tailored to innovative regional companies, will help catalyze a robust innovation/entrepreneurial ecosystem in the SBE Region, helping to make the region "sticky" for not only opportunities that are generated from the IDEA Center but also the development of opportunities from the broader region. The Partnership will target the region's resources to the most promising entrepreneurs that, in turn, will drive economic growth in the future by helping to diversify the economy. There is already evidence that this is naturally forming in the regional market around the emerging data analytics cluster (see previous IT/data analytics text box). The goal would be to further catalyze the growth of this emerging cluster while working to identify other areas of opportunity.

What Others Do: Pittsburgh Life Sciences Greenhouse (PLSG)

As a dedicated organization focused on growing emerging life-science companies, PLSG combines incubation and early venture financing with a successful effort to advance entrepreneurial talent to lead life science innovations. From 2001 to 2017, PLSG has worked with over 470 companies, and has made approximately $22 million of direct investments to 80 companies, which has leveraged over $1.5 billion of additional capital for the region. One of the keys to PLSG's success—that addressed a significant challenge for the region—is an Executive-in-Residence (EIR) program, which was started to provide emerging life-sciences companies with domain-specific, C-level leadership, providing executive talent to help form companies; subject matter experts to guide companies; executives to run companies; and program managers and directors to help companies grow. In 2005, the PLSG expanded the EIR Program to extend its areas of support and to add specialists for the life sciences community that will work more directly with institutional and private investors and the venture capital industry at large—and renamed it the Executive Program. Since inception, 48 executives have participated in the PLSG EIR program, with more than 60 percent of them still in the region working directly with a life science company. The importance of the Executive Program is that the 30 companies that now employ former PLSG EIRs make up a large share of the 80 life sciences companies that PLSG has invested in over its 15+ years.

Action 3: Create an indigenous pipeline of risk capital funds to invest in entrepreneurial efforts in the region.

The costs associated with developing and taking a product or service to market are substantial. Major costs incurred include the cost of assessing the market to determine the competition, the likely market, and the price points for competitive advantage; developing a prototype; preparing a marketing and sales plan; and scaling up for manufacturing if applicable. Finally, actual product distribution, sales, and marketing must be undertaken. These activities require the availability of sufficient capital to finance business growth.

Yet, few sources of funding bridge the gap between the points at which (1) a discovery has been identified and demonstrated and (2) a business case has been validated and venture or other debt capital can be obtained. It is also difficult to obtain seed and early-stage investment because venture funds, as they have become larger, tend to make larger, later-stage investments. As a result, angel investors have also moved downstream (further away from pre-seed and seed investments), making more post-seed and later-stage investments than previously.

Through the efforts of Startup South Bend-Elkhart, the region has aggressively focused over the last year on working to develop a pipeline of risk capital through its partnership with Elevate Ventures. However, many entrepreneurs noted that there is insufficient indigenous risk capital in the region. To help overcome this shortage of investment capital, the SBE Region must focus on creating both indigenous sources of capital and connections to sources of capital that have been established proximate to metropolitan centers, primarily Chicago and Indianapolis. The following are specific recommendations.

Create a Proof-of-Concept Fund: It has become increasingly common to provide funding for activities needed to determine the commercial potential of a discovery and to advance the technology to the point at which a commercial partner can be found. Proof-of-Concept (PoC) funds support prototype development, testing and validation, and marketing research and are usually provided in the form of a grant that does not require any repayment. Such funding is often needed to commercialize IP at the highest value—and sometimes to license it at all—as such technology usually is at an early stage of development and requires additional studies or a working prototype before it can be shown to have commercial value. It also is necessary to surround the original discovery with additional patents and protections. Such activities are almost never fundable through conventional peer-reviewed federal programs and, if they are to take place at all, must be separately funded under a different set of criteria focused mainly on economic development.

The SBE Region has the opportunity to leverage the IDEA Center's efforts through its commercialization engine process. There has already been an agreement put in place to accept 10 community start-ups into the program each year. However, to prepare these opportunities for entry, there is often a need to advance the ideas further. A PoC fund would enable the region to invest in its earliest-stage opportunities to help them prepare for entry into the IDEA Center or, for those opportunities that are not a good fit with the IDEA Center's focus, to continue to advance them within the community.

Organize a Regional Angel Investment Fund: There is considerable concern that the number of angel investors in the region is still quite small and not increasing fast enough. Unless there are some success stories, e.g., successful exits, entrepreneurs may face not only insufficient venture fund availability but also insufficient angel fund availability as well. For these reasons, more angel investors need to become involved in these investments and an angel fund needs to be organized in the region. It is important to note that there is already an organized angel fund composed of Notre Dame Alums—IrishAngels—which is an investing group dedicated to furthering start-up growth through early-stage investments in which a founder, Board member, or active investor is a student, graduate, parent, or faculty member at the University of Notre Dame. However, IrishAngels invests further downstream than other angel groups, seeking high potential start-ups for seed and Series A investments (about $1 million to $3 million). Prospective portfolio companies should have a management team with relevant experience, high growth potential, a completed product or service, and a thoughtfully constructed growth strategy. It will be important to leverage this unique asset, but it is important to recognize that the fund does not address early-stage capital needs and is not necessarily indigenous to the region. There is a need for an angel fund that helps capture the wealth of the individuals who reside in the region as well as invests earlier in the innovation continuum.

There have been efforts to create a formal angel network; however, due to lack of deal flow, it has been difficult to develop a model that is of interest to investors. One solution would be to syndicate deals from other larger angel investor networks in Indianapolis, Chicago, etc., so that regional investors begin to feel comfortable with the process and more likely to fund entrepreneurs in the region.

Efforts of other angel investment networks demonstrate the ability of regional efforts to turn ideas into new enterprises. However, a coordinating focus of these efforts is needed, as well as sustained brokering, coordinating, screening and review, and coaching set of roles, to maintain and expand these angel networks. An angel investor network is critical to moving ideas into enterprises in the SBE Region.

Professional management of such a fund would help undertake the screening and review of ideas for presentation to angels, seeking and securing the involvement of potential angel investors, and providing linkages to various technology-based economic development organizations. This role could potentially be assumed by the Elevate Indiana presence in the region.

Tap into/Create Pre-Seed, Seed, and Working Capital (Debt) Funds: As the amount of deal flow increases through these efforts, the risk capital ecosystem of the region will need to be prepared to tap into statewide/regional pre-seed funds and consider creating an SBE Regional pre-seed fund. In addition, it will be important to address the needs for working capital (debt) manufacturing, supply-chain support firms, and nontechnical firms as other targeted-industry clusters begin to see entrepreneurial growth. A regional working capital fund, supported by financial institutions in the region, may be of assistance.

If implemented, this comprehensive continuum of indigenous sources of risk capital will help further foster a robust innovation/entrepreneurial ecosystem in the SBE Region, helping, as noted above, to make the region "sticky" for not only opportunities that are generated from the IDEA Center but also the development of opportunities from the broader region.

Establish a First Customer Program: Another important element within the risk capital continuum is the ability to link start-up companies with their first customers. Particularly in technology areas relevant to the region's existing industrial base, it will be critical for the region's anchor industries to serve as first customers and early adopters so that the innovations can be deployed into the field to prove their efficacy. By linking emerging companies to the SBE Region's industry anchors, start-ups firms will be able to firmly establish their roots in the region as they grow and scale at a more rapid pace.

Strategy Three: Develop, Retain, and Attract the Talent that the SBE Region's Existing and Emerging Industries Demand

Rationale

In the 21st century, human capital is the key differentiator between economically prosperous regions and declining ones. Without skilled people, innovation cannot occur and advanced technologies cannot be deployed. Without skilled technical and managerial personnel, capital is extremely difficult, if not impossible, to secure. Natural resources have ceased to be critical drivers of economic advancement. It is the talent of people that drives economic success and is the fuel of the innovation and knowledge economy. It is the nations, regions, communities, and individual firms that have the most highly skilled workforce that will be the most productive. They will dominate markets by delivering the best products and services at the lowest costs and, as a result, will earn the highest profits.

> *Among all the riches a nation may possess, its people—its human resources, its human capital—is the most important. The value of this human resource depends not on size, however, but on the occupational and intellectual skills its members possess.*
>
> Gray and Herr

Talent can and must be an essential part of any strategy to create a competitive advantage. If a firm does not use its workforce as anything more than a low-skill, low-wage, and high-turnover commodity, then it will not generate or retain any type of enduring market advantage in a marketplace that is

increasingly emphasizing the use of high-tech tools that add value for suppliers and end customers. So, how does human capital factor into a region's comparative advantage?

Simply put, human capital is one of the few market factors that are locally based and have the potential to create a comparative advantage that can differentiate a state, region, or firm from its competition. A region cannot change its physical location, so its location advantages are fixed. Firms can purchase new and emerging technology; but, if these are "off-the-shelf" technologies, then they are available to the competition. In contrast, human capital is a locally provided and locally managed resource, thus able to be differentiated from other regions. In addition, human capital is an essential element in implementing advanced technology solutions. The quantity, quality, and management of human capital are competitive factors very much in local control.

A supply of qualified, highly skilled workers is critical to the development and sustainability of an innovation economy. All industries require a supply of qualified, trained workers at all levels. Successful regions are able to develop, retain, and attract a supply of talent that meets its existing and emerging industrial needs.

The SBE Region's Current Situation

Access to workforce and talent is the top challenge or concern expressed by regional employers in interviews, particularly in an extremely tight labor market where unemployment rates have dipped to 3 percent, or even 2 percent in some parts of the region. Regional companies are in "high-growth mode" and many are desperate for workers.

Regional workforce demand spans the spectrum of skill needs, but an analysis of high-demand occupations[26] reveals a particularly strong demand during this economic expansion for middle-skilled workers—those occupations that generally require significant education, experience, and/or training beyond high school but less than a bachelor's degree. This is not surprising given the extremely high concentration of manufacturing and production jobs, which require an especially large number of middle-skilled workers. The assessment of high-demand occupations revealed more than 40 distinct job categories with middle-skill requirements. Some of the largest, fastest-growing occupations include the following:

- Team assemblers: 20,162 regional jobs, 51 percent job growth since 2010;
- Heavy and tractor-trailer truck drivers: 3,690 regional jobs, 25 percent job growth since 2010;
- Sales representatives, manufacturing: 3,623 regional jobs, 26 percent job growth since 2010;
- Maintenance and repair: 3,581 regional jobs, 23 percent job growth since 2010;
- Assemblers and fabricators (all other): 3,067 regional jobs, 62 percent job growth since 2010; and
- Welders, cutters, solderers: 2,716 regional jobs, 34 percent job growth since 2010.

The list goes well beyond these jobs, and even into higher-skilled areas where manufacturers told the project team that they have specific skill needs that are challenging to find and to hire, including

[26] TEConomy's analysis of "high-demand" occupations included an assessment of those regional occupations with a sizable base of jobs, that were growing during the expansion (2010–2017), and have outpaced overall regional occupational growth (19 percent plus). For the list of these occupations and their employment levels, location quotients, and growth rates, see Appendix A.

mechanical engineering; IT expertise, particularly within manufacturing to help integrate and deploy automation; and data analytics/analysts. These areas are reinforced by the high-demand analysis pointing to the following high-skilled areas that typically require a bachelor's degree or higher for entry:

- Engineering:
  - Industrial engineers: 832 regional jobs, 23 percent job growth since 2010; and
  - Mechanical engineers: 672 regional jobs, 25 percent job growth since 2010.
- IT:
  - Network, computer systems administrators: 640 regional jobs, 19 percent job growth since 2010; and
  - Computer programmers: 419 regional jobs, 22 percent job growth since 2010.

Whatever the specific talent need, regional employers express common challenges in attracting, recruiting, hiring, and retaining workforce in the region, including the following dynamics:

- Talent attraction to rural, smaller communities is difficult, particularly with younger people.
- High turnover is resulting from workers leaving for higher pay.
- With limited connections with Notre Dame graduates, regional retention is a challenge.
- Ivy Tech is a good local resource, but program scale and quality of graduates are questionable.
- Aging workforce is driving needs for skilled, technical talent.

In response to workforce and talent challenges, employers are turning to automation in the form of robotic systems as both a complement to but also potential current or future replacement for workers. In discussions with employers, this integration of automation technologies has largely not replaced workers, at least not yet.

What is clear is that employers are struggling to meet workforce and talent demands in a high-growth economy, with pressures to increase wages, though even the promise of high-paying jobs has not solved the challenges of recruiting and attracting talent into the region. At the same time, discussions with both employers and Notre Dame faculty reveal extremely limited connections for student internships and hiring, reflective of the University's national and international excellence that typically leads to opportunities well beyond the SBE Region for employment and experiential learning while in school. Both sides, however, are opening their lens to the array of opportunities to connect and to better understand these opportunities for students. For these reasons, and facing these dynamics, a multifaceted set of strategies is needed that will focus on upskilling the current workforce, recruiting/attracting talent into the region, and retaining those individuals in the region or who have meaningful connections to the region (e.g., alumni).

The SBE Region must be able to develop, retain, and attract the talent that meets industrial demand to ensure its economic drivers remain globally competitive and new industries can grow and scale. The following recommendations seek to obtain these goals.

Action 4: Create and scale experiential learning opportunities to connect students with industry as well as retrain incumbent workers.

Within professional degree programs, there is a long tradition of including field experiences as a way to build practitioner skills and facilitate the move from theory to practice. Unfortunately, this highly

effective practice is often not deployed in the advanced manufacturing and related fields. By missing out on this opportunity, individuals are often not able to connect classroom relevance to the professional world. Experiential learning is beneficial for both students and employers: they offer career exploration and skills application for students and provide employers with workers who are creative and enthusiastic, are able to assist with projects, and are open for mentorship. Transitioning students into full-time employees is also a proven time- and cost-saving recruiting method.

However, experiential learning programs are not easy to develop and implement. While large corporations often have the internal resources to develop such efforts, most small- and medium-sized firms do not, and entrepreneurial efforts are at an even further disadvantage. To overcome this barrier, it is recommended that the following five initiatives be pursued.

Expand Apprenticeship Programs and Increase Awareness of Career Opportunities.

To expose students to local career opportunities and the postsecondary pathways that lead to success in future careers, it is recommended that the region implement activities like “Career Quest,” which help young students explore potential jobs in all sectors, and support an expansion of “Manufacturing Day” programs, which help students learn about the region’s dominant industry.

Competency-based certificates and credentials that are of value to the current and future workforce can help the traditional pipeline of workers and those already working in companies grow personal income and help companies increase automation. Specifically, increasing the number of certificates and credentials in advanced manufacturing will support the mobility cluster and its supply chain.

Several pilot apprenticeship programs are underway or being explored in the region. The Horizon Education Alliance, a nonprofit organization created in 2012 by Elkhart County education and business leaders, is currently developing a master plan for implementing a manufacturing apprenticeship program. The Industrial Manufacturing Technician (IMT) apprenticeship program supports incumbent workers employed by members of the Advanced Manufacturing Sector Partnership (AMSP) in Elkhart County. Each program is registered with the Department of Labor Office of Apprenticeship as a “hybrid” approach with both instructor-led learning and competency-based assessment of on-the-job experience. The pre-apprenticeship program (for high school students) includes prescreening, assessments, remediation, and orientation. The instructor-led learning that utilizes Certified Production Technician (CPT) modules is being taught by Ivy Tech instructors in the evenings at local high school labs.

Since its inception, the AMSP has received roughly $9.5 million to support its programming, including local investments of $4.3 million; a Skill UP Indiana! award of $1.7 million, presented by Indiana’s Department of Workforce Development; and $3.2 million from the Labor Institute for Training within the U.S. Department of Labor. In addition, the Lumina Foundation named Elkhart County as a "talent hub," a distinction awarded to 24 sites in the country. Through this recognition, the county will receive $275,000 in grant money over 2.5 years.

It is recommended that the region support an expansion of apprenticeship efforts to serve the manufacturing talent needs of all counties in the region. Currently, the AMSP is documenting each step of the apprenticeship program for each partner involved in IMT. This model can be replicated for a higher-level apprenticeship program in mechatronics, adapted for apprenticeships in response to needs articulated by additional sector partnerships, and replicated for higher-level apprenticeships within the occupations within these additional sectors. Additional funding could be utilized to identify and raise

awareness of the priority pathways in demand across the region and co-design the necessary learning experiences such as industry-infused project-based learning, apprenticeships, etc., to create the needed workforce.

For example, to support emerging industry, it is recommended that the region leverage the collaborative potential among the institutions of higher education to ensure career exposure and launch and scale a talent development program for data analytics.

Provide Lifelong Learning Opportunities.

Retraining incumbent workers to meet future demands and leverage economic opportunities depends upon a culture of lifelong learning. The Drucker Institute has partnered with key stakeholders in the City of South Bend to implement the Lifelong Learning System, ensuring that learning is relevant and accessible for the most economically disadvantaged. The system is both digital and physical and integrates the most effective existing resources and makes them accessible and inviting for the entire community.

The digital portal will allow residents to understand what job skills are most needed based on real-time market information, see where those skills are being taught, develop career skills, and keep a record of what has been learned. This approach can strengthen the labor force by increasing employment and expanding participation in the workforce. By cultivating a culture of lifelong learning, the region's talent pool will be in the habit of acquiring new knowledge and skills so that they are not at risk of being displaced by industry's adoption of new technologies and automation.

The model is being developed with the ability to be replicated, and it is recommended that the model be expanded across the region.

Leverage the State's 21st Century Scholars Program.

The State of Indiana offers scholarships providing students up to 4 years of undergraduate tuition and providing help to ensure students succeed in college. The Scholar Success Program ensures that students complete specific steps to keep them on track for college and career success, including taking a career interests assessment and getting workplace experience, which support the recommendation to increase career exploration and experiential learning. To ensure the greatest number of current and future students advance through the talent pipeline successfully, the region should increase awareness and participation of students taking advantage of the State of Indiana's 21st Century Scholars Program and successfully earning college degrees.

Place Talent into Regional Firms to Help Meet Industrial Innovation Needs (Node 4 of the Institute for Industry Innovation).

One way to build and retain talent is to establish personal relationships with students while they are still in school, whether it be high school or 2-year, undergraduate, or graduate programs. Experience shows that efforts such as internships and co-op programs can be effective in increasing the retention rate of graduates, reducing their out-migration to other states and regions. The SBE Region needs to develop programs to support such efforts as it is extremely difficult for a small- to medium-sized company to develop such programs on their own. Such an effort will not only keep students in the region, but also expose firms to new skills and approaches as they address their product development needs.

Many benefits could accrue from an enhanced internship/co-op function, including the following:

- Increasing the perceived value of education, to both prospective students and parents. Parents increasingly desire evidence that their children are receiving both theoretical and practical sets of experiences and an education that will prepare them ultimately for the world of work.
- Providing important real-world feedback to curriculum and instruction, helping to ensure that course content, programs of study, and laboratory experiences are high quality.
- Increasing retention rates of students in the region by making early connections with regional industry.

It is recommended that a function of the Institute for Industry Innovation (Strategy One Action1) include the development and oversight of an internship program focused on the region's mobility industry. Students and faculty advisors would be drawn from all of the region's institutions of higher education, encompassing a large pool of talent and skill sets. Internships would be defined very broadly, and could include both of the following:

- Traditional placement of a student within a company for a set period of time; and,
- A project-driven opportunity, with oversight by a professor, that engages the student to meet a specific need that a company has identified.

The bottom line is that internships and other experiential learning activities help make students aware of local employers and also help local employers recruit future workers. An added benefit is that internships can provide students with needed job experience that employers value very highly.

Expand enFocus's Efforts to Include Industrial Fellowships.

It is important to recognize the regional efforts underway to develop and retain high-skilled talent in the SBE Region. To this end, a key innovative program within the region has been enFocus. In 2012, enFocus was conceived and implemented in South Bend. The initial program model employed seven "fellows," typically recent graduates with master's degrees (e.g., those graduating from Notre Dame's ESTEEM [Engineering, Science, and Technology Entrepreneurship Excellence Masters] Program) in a year-long engagement, who were then matched with sponsor projects largely around specific problems or challenges in "civic innovation." This has taken many forms, with fellows developing solutions to problems within city and regional government and economic development, healthcare, local education, and other areas. The program has utilized a shared expense approach for funding fellows, with sponsors and enFocus both providing funding for salaries.

The model has matured since its inception and is reaching a larger scale. Recruiting is now happening year-round with both full- and part-time fellows and expansion into internships. The program, in 2013, received funding from the Lilly Endowment in the form of a 5-year grant to expand its efforts with the goal of reversing the region's out-migration dynamic. The program to date has employed 60 fellows and more than 600 interns with a strong retention rate following these engagements, with enFocus reporting 70 percent of fellows and approximately 40 percent of interns remaining in the region immediately following their enFocus projects. Program fellows have incubated more than 20 new businesses in the region, according to enFocus.

It is recommended that the region support an expansion of enFocus's efforts to support fellows who will engage with the industrial base of the region (in areas of engineering, science, and business operations) and not focus solely on civic innovation. enFocus already has expanded into Elkhart County. Program

leaders are open to engaging further with private companies, though they have not yet arranged for a matching funding approach on this type of arrangement. It is recommended that funding be provided so that an Industrial Fellows initiative can be created.

Action 5: Launch a marketing/branding campaign to attract alumni back to the SBE Region by creating an Alumni Recruitment Program.

To help overcome the talent deficit issues being experienced in the region's emerging industrial base (as well as the start-up community), it will be important to attract to the region senior and mid-level professionals demanded by emerging industry. As the innovation and entrepreneurial efforts help drive economic growth, it will be critical to be able to attract talent from outside the region to support these opportunities. The SBE Region is uniquely positioned to be able to pursue this strategy due to the affinity of Notre Dame's alumni base to the institution and region. The SBE Region should seek to leverage this unique comparative advantage by working to attract talent to the region that already has a natural affinity to it. By targeting Notre Dame alumni, the region will catalyze the amount of talent in critical leadership positions in its most innovative firms.

Because of the out-migration of alumni, particularly Notre Dame alumni, many individuals who have received their advanced education in the region have pursued successful careers elsewhere, yet many of these people may wish to return to the region if an opportunity to do so was presented. Of particular interest would be those people who have successfully started and managed businesses or who have the technical skills needed by SBE's existing and emerging industry clusters.

Other regions have pursued efforts to reach out to publicize the quality of career opportunities, quality of place, and even help in matching workers to jobs in their regions. In Huntsville, Alabama, home to the Army's Redstone Arsenal, the regional Chamber of Commerce has an active marketing campaign to attract high-skilled workers to the region, focusing on Huntsville as "a smart place." In this effort, it features all of the live-work-play advantages that Huntsville offers to technology and other high-skilled professionals, plus features a "find a job" website that provides information about civilian jobs at Redstone Arsenal and features a job matching service for job seekers and employers. A more hands-on focus to match workers with specific skill sets to employers is the Pittsburgh Digital Greenhouse, which in its early years focused on helping in talent recruitment for firms coming to Pittsburgh to pursue lab-on-a-chip technology development, and later focused more broadly on electronics and robotics. What has been learned from these efforts is the importance of creating an initiative that develops and maintains dynamic databases of jobs and skilled workers, conducts outreach marketing, and serves as a key point of access for job seekers and employers in selected areas.

Key to the success of this attraction program will be the creation of a Notre Dame Alumni Recruitment Program, utilizing the vast alumni network of Notre Dame and serving as an immediate connection point to the opportunities being created in the SBE Region. It will be critical to develop a long-term alumni marketing campaign to keep them abreast of all of the exciting initiatives taking place within the region, as well as to develop a database of regional opportunities and matching them to alumni with relevant experience to directly target those individuals. While it is recommended that the initiative focus its early efforts on alumni of Notre Dame due to the sheer number of engaged graduates, it is envisioned that

the initiative in time could be expanded to focus on all alumni of the region working in partnership with their respective institutions of higher education.

Summary

To truly change the tide of the economy of the SBE Region will require that the region focus its investments on three strategic priorities that leverage and complement existing efforts while catalyzing long-term economic growth across the state (Table 8).

Table 8. Recommended Strategies and Actions to Position the SBE Region for Long-Term Economic Growth

Strategy	Targeted Actions to Pursue
Strategy One **Foster the Infusion of Advanced Innovation Processes, Products, and Techniques into the SBE Region's Advanced Manufacturing Industries, Starting with the Mobility Meta-Cluster and its Supply Chain**	**Action 1:** Create an Institute for Industry Innovation, in partnership with regional industrial leaders, University of Notre Dame, Purdue, and other regional institutions of higher education, that focuses on infusing advanced innovation processes, products, and techniques into the SBE Region's industrial base.
Strategy Two **Catalyze the Entrepreneurial Ecosystem to Diversify the Economy and Drive Future Economic Growth**	**Action 2:** Expand the role of the SBE Regional Partnership to provide entrepreneurial support services to innovative start-up companies and coordinate with other entrepreneurial initiatives in the region.
	Action 3: Create an indigenous pipeline of risk capital funds to invest in entrepreneurial efforts in the region.
Strategy Three **Develop, Retain, and Attract the Talent that the SBE Region's Existing and Emerging Industries Demand**	**Action 4:** Create and scale experiential learning opportunities to connect students with industry as well as retrain incumbent workers.
	Action 5: Launch a marketing/branding campaign to attract alumni back to the SBE Region by creating an Alumni Recruitment Program.

While the funding for these critical initiatives will be significant, they will also be transformative for SBE's regional economy—developing an innovation ecosystem structured to leverage innovation and scale significant growth.

Conclusion

The SBE Region is in a unique economic position. The region's industrial base survived the Great Recession and is now flourishing in this period of sustained expansion; and yet, the underlying root causes of the economic downturn remain, leaving the region economically susceptible to business cycles in the future. Recognizing that status quo can no longer be the modus operandi, regional leaders have come together in unprecedented collaboration to form the SBE Regional Partnership, and in a relatively short period of time, have made great strides in moving forward with strategic efforts to enhance the economic viability and livability of the region.

Yet, the challenge for the SBE Region is to determine how best to foster economic growth and broad community prosperity by focusing its efforts on building linkages between the region's industrial base and its research assets, thereby improving key facets of the innovation ecosystem from workforce and talent, to diversified industry growth, to creating a culture and ecosystem where entrepreneurs and new businesses can thrive.

The SBE Region has the opportunity to leverage its current momentum by making critical investments today that will enable the region to "leap forward" and become a leading job- and wealth-generating economy over the next decade. In today's global knowledge-based economy, the recipe for economic success is quite simple—the SBE Region needs to focus its economic development investments to ensure not only that its existing industry drivers can raise their level of competitiveness and added value, but also that it can identify new drivers of innovation to improve the region's economic prospects. This investment strategy is designed to address these challenges and identify the elements and ingredients to successfully position the region to mitigate its challenges, build on its strengths, seize its opportunities, and put into action a set of strategies that catalyze economic and community prosperity.

The analysis suggests that true transformation of the region's economy will require the following:

- Fostering the infusion of advanced innovation processes, products, and techniques into the SBE Region's advanced manufacturing industries, starting with the mobility meta-cluster and its supply chain;
- Catalyzing the entrepreneurial ecosystem to diversify the economy and drive future economic growth; and
- Developing, retaining, and attracting the talent that the SBE Region's existing and emerging industries demand.

Taking advantage of these opportunities requires key strategic investments that will require the broad support and collaboration of the entire region. By working together, the opportunity for the SBE Region to grow its economic base and increase community prosperity is substantial. If successful, it is expected that what will emerge are public-private-academic partnership initiatives that will advance the region for the coming decades.

Appendix A: Industry Cluster Detail

Table A-1: Definitions of the South Bend-Elkhart (SBE) Region's Industry Clusters Based on the North American Industry Classification System (NAICS)

NAICS Code	Industry Cluster and NAICS Industry Description
Cabinets, Furniture, and Related Products	
337110	Wood Kitchen Cabinet and Countertop Manufacturing
337121	Upholstered Household Furniture Manufacturing
337122	Nonupholstered Wood Household Furniture Manufacturing
337124	Metal Household Furniture Manufacturing
337125	Household Furniture (except Wood and Metal) Manufacturing
337127	Institutional Furniture Manufacturing
337129	Wood Television, Radio, and Sewing Machine Cabinet Manufacturing
337211	Wood Office Furniture Manufacturing
337212	Custom Architectural Woodwork and Millwork Manufacturing
337214	Office Furniture (except Wood) Manufacturing
337215	Showcase, Partition, Shelving, and Locker Manufacturing
337910	Mattress Manufacturing
337920	Blind and Shade Manufacturing
Engineering/Environmental Technical Services	
541330	Engineering Services
541380	Testing Laboratories
541620	Environmental Consulting Services
541690	Other Scientific and Technical Consulting Services
541712	Research and Development in the Physical, Engineering, and Life Sciences (except Biotechnology)
Hospitals and Health Services	
621410	Family Planning Centers
621420	Outpatient Mental Health and Substance Abuse Centers
621491	HMO Medical Centers
621492	Kidney Dialysis Centers
621493	Freestanding Ambulatory Surgical and Emergency Centers
621498	All Other Outpatient Care Centers
621512	Diagnostic Imaging Centers
621991	Blood and Organ Banks
622110	General Medical and Surgical Hospitals
622210	Psychiatric and Substance Abuse Hospitals
622310	Specialty (except Psychiatric and Substance Abuse) Hospitals
IT Services	
518210	Data Processing, Hosting, and Related Services

NAICS Code	Industry Cluster and NAICS Industry Description
541511	Custom Computer Programming Services
541512	Computer Systems Design Services
541513	Computer Facilities Management Services
541519	Other Computer Related Services
Life Sciences	
325411	Medicinal and Botanical Manufacturing
325412	Pharmaceutical Preparation Manufacturing
325413	In-Vitro Diagnostic Substance Manufacturing
325414	Biological Product (except Diagnostic) Manufacturing
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
334517	Irradiation Apparatus Manufacturing
339112	Surgical and Medical Instrument Manufacturing
339113	Surgical Appliance and Supplies Manufacturing
339114	Dental Equipment and Supplies Manufacturing
339115	Ophthalmic Goods Manufacturing
541711	Research and Development in Biotechnology
621511	Medical Laboratories
Manufactured Buildings and Building Products	
321211	Hardwood Veneer and Plywood Manufacturing
321212	Softwood Veneer and Plywood Manufacturing
321213	Engineered Wood Member (except Truss) Manufacturing
321214	Truss Manufacturing
321219	Reconstituted Wood Product Manufacturing
321911	Wood Window and Door Manufacturing
321912	Cut Stock, Resawing Lumber, and Planing
321918	Other Millwork (including Flooring)
321991	Manufactured Home (Mobile Home) Manufacturing
321992	Prefabricated Wood Building Manufacturing
321999	All Other Miscellaneous Wood Product Manufacturing
327991	Cut Stone and Stone Product Manufacturing
327993	Mineral Wool Manufacturing
332311	Prefabricated Metal Building and Component Manufacturing
332312	Fabricated Structural Metal Manufacturing
332321	Metal Window and Door Manufacturing
332322	Sheet Metal Work Manufacturing
332323	Ornamental and Architectural Metal Work Manufacturing
332510	Hardware Manufacturing
332913	Plumbing Fixture Fitting and Trim Manufacturing

NAICS Code	Industry Cluster and NAICS Industry Description
332996	Fabricated Pipe and Pipe Fitting Manufacturing
332998	Enameled Iron and Metal Sanitary Ware Manufacturing
Metal Processing and Products	
331111	Iron and Steel Mills
331112	Electrometallurgical Ferroalloy Product Manufacturing
331210	Iron and Steel Pipe and Tube Manufacturing from Purchased Steel
331221	Rolled Steel Shape Manufacturing
331222	Steel Wire Drawing
331311	Alumina Refining
331312	Primary Aluminum Production
331314	Secondary Smelting and Alloying of Aluminum
331315	Aluminum Sheet, Plate, and Foil Manufacturing
331316	Aluminum Extruded Product Manufacturing
331319	Other Aluminum Rolling and Drawing
331411	Primary Smelting and Refining of Copper
331419	Primary Smelting and Refining of Nonferrous Metal (except Copper and Aluminum)
331421	Copper Rolling, Drawing, and Extruding
331422	Copper Wire (except Mechanical) Drawing
331423	Secondary Smelting, Refining, and Alloying of Copper
331491	Nonferrous Metal (except Copper and Aluminum) Rolling, Drawing, and Extruding
331492	Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum)
331511	Iron Foundries
331512	Steel Investment Foundries
331513	Steel Foundries (except Investment)
331521	Aluminum Die-Casting Foundries
331522	Nonferrous (except Aluminum) Die-Casting Foundries
331524	Aluminum Foundries (except Die-Casting)
331525	Copper Foundries (except Die-Casting)
331528	Other Nonferrous Foundries (except Die-Casting)
332111	Iron and Steel Forging
332112	Nonferrous Forging
332114	Custom Roll Forming
332115	Crown and Closure Manufacturing
332116	Metal Stamping
332117	Powder Metallurgy Part Manufacturing
332211	Cutlery and Flatware (except Precious) Manufacturing
332212	Hand and Edge Tool Manufacturing
332213	Saw Blade and Handsaw Manufacturing
332214	Kitchen Utensil, Pot, and Pan Manufacturing

NAICS Code	Industry Cluster and NAICS Industry Description
332313	Plate Work Manufacturing
332410	Power Boiler and Heat Exchanger Manufacturing
332420	Metal Tank (Heavy Gauge) Manufacturing
332431	Metal Can Manufacturing
332439	Other Metal Container Manufacturing
332611	Spring (Heavy Gauge) Manufacturing
332612	Spring (Light Gauge) Manufacturing
332618	Other Fabricated Wire Product Manufacturing
332710	Machine Shops
332721	Precision Turned Product Manufacturing
332722	Bolt, Nut, Screw, Rivet, and Washer Manufacturing
332811	Metal Heat Treating
332812	Metal Coating, Engraving (except Jewelry and Silverware), and Allied Services to Manufacturers
332813	Electroplating, Plating, Polishing, Anodizing, and Coloring
332911	Industrial Valve Manufacturing
332912	Fluid Power Valve and Hose Fitting Manufacturing
332919	Other Metal Valve and Pipe Fitting Manufacturing
332991	Ball and Roller Bearing Manufacturing
332992	Small Arms Ammunition Manufacturing
332993	Ammunition (except Small Arms) Manufacturing
332994	Small Arms Manufacturing
332995	Other Ordnance and Accessories Manufacturing
332997	Industrial Pattern Manufacturing
332999	All Other Miscellaneous Fabricated Metal Product Manufacturing
333511	Industrial Mold Manufacturing
333512	Machine Tool (Metal Cutting Types) Manufacturing
333513	Machine Tool (Metal Forming Types) Manufacturing
333514	Special Die and Tool, Die Set, Jig, and Fixture Manufacturing
333515	Cutting Tool and Machine Tool Accessory Manufacturing
333612	Speed Changer, Industrial High-Speed Drive, and Gear Manufacturing
333992	Welding and Soldering Equipment Manufacturing
Micro-Electronic Components	
334412	Bare Printed Circuit Board Manufacturing
334413	Semiconductor and Related Device Manufacturing
334414	Electronic Capacitor Manufacturing
334415	Electronic Resistor Manufacturing
334416	Electronic Coil, Transformer, and Other Inductor Manufacturing
334417	Electronic Connector Manufacturing
334418	Printed Circuit Assembly (Electronic Assembly) Manufacturing

NAICS Code	Industry Cluster and NAICS Industry Description
334419	Other Electronic Component Manufacturing
335314	Relay and Industrial Control Manufacturing
Motor Vehicles	
333924	Industrial Truck, Tractor, Trailer, and Stacker Machinery Manufacturing
336111	Automobile Manufacturing
336112	Light Truck and Utility Vehicle Manufacturing
336120	Heavy Duty Truck Manufacturing
336211	Motor Vehicle Body Manufacturing
336212	Truck Trailer Manufacturing
336311	Carburetor, Piston, Piston Ring, and Valve Manufacturing
336312	Gasoline Engine and Engine Parts Manufacturing
336321	Vehicular Lighting Equipment Manufacturing
336322	Other Motor Vehicle Electrical and Electronic Equipment Manufacturing
336330	Motor Vehicle Steering and Suspension Components (except Spring) Manufacturing
336340	Motor Vehicle Brake System Manufacturing
336350	Motor Vehicle Transmission and Power Train Parts Manufacturing
336360	Motor Vehicle Seating and Interior Trim Manufacturing
336370	Motor Vehicle Metal Stamping
336391	Motor Vehicle Air-Conditioning Manufacturing
336399	All Other Motor Vehicle Parts Manufacturing
339991	Gasket, Packing, and Sealing Device Manufacturing
Other Transportation Equipment	
336411	Aircraft Manufacturing
336412	Aircraft Engine and Engine Parts Manufacturing
336413	Other Aircraft Parts and Auxiliary Equipment Manufacturing
336414	Guided Missile and Space Vehicle Manufacturing
336415	Guided Missile and Space Vehicle Propulsion Unit and Propulsion Unit Parts Manufacturing
336419	Other Guided Missile and Space Vehicle Parts and Auxiliary Equipment Manufacturing
336612	Boat Building
336991	Motorcycle, Bicycle, and Parts Manufacturing
Polymers, Plastics, and Rubber	
325211	Plastics Material and Resin Manufacturing
325212	Synthetic Rubber Manufacturing
325510	Paint and Coating Manufacturing
325520	Adhesive Manufacturing
326111	Plastics Bag and Pouch Manufacturing
326112	Plastics Packaging Film and Sheet (including Laminated) Manufacturing
326113	Unlaminated Plastics Film and Sheet (except Packaging) Manufacturing
326121	Unlaminated Plastics Profile Shape Manufacturing

NAICS Code	Industry Cluster and NAICS Industry Description
326122	Plastics Pipe and Pipe Fitting Manufacturing
326130	Laminated Plastics Plate, Sheet (except Packaging), and Shape Manufacturing
326140	Polystyrene Foam Product Manufacturing
326150	Urethane and Other Foam Product (except Polystyrene) Manufacturing
326160	Plastics Bottle Manufacturing
326191	Plastics Plumbing Fixture Manufacturing
326192	Resilient Floor Covering Manufacturing
326199	All Other Plastics Product Manufacturing
326211	Tire Manufacturing (except Retreading)
326212	Tire Retreading
326220	Rubber and Plastics Hoses and Belting Manufacturing
326291	Rubber Product Manufacturing for Mechanical Use
326299	All Other Rubber Product Manufacturing
Private Colleges and Universities	
611210	Junior Colleges
611310	Colleges, Universities, and Professional Schools
RV, Travel Trailers, and Campers	
336213	Motor Home Manufacturing
336214	Travel Trailer and Camper Manufacturing
336999	All Other Transportation Equipment Manufacturing
Transportation, Distribution, and Logistics	
423110	Automobile and Other Motor Vehicle Merchant Wholesalers
423120	Motor Vehicle Supplies and New Parts Merchant Wholesalers
423130	Tire and Tube Merchant Wholesalers
423140	Motor Vehicle Parts (Used) Merchant Wholesalers
423210	Furniture Merchant Wholesalers
423220	Home Furnishing Merchant Wholesalers
423310	Lumber, Plywood, Millwork, and Wood Panel Merchant Wholesalers
423320	Brick, Stone, and Related Construction Material Merchant Wholesalers
423330	Roofing, Siding, and Insulation Material Merchant Wholesalers
423390	Other Construction Material Merchant Wholesalers
423410	Photographic Equipment and Supplies Merchant Wholesalers
423420	Office Equipment Merchant Wholesalers
423430	Computer and Computer Peripheral Equipment and Software Merchant Wholesalers
423440	Other Commercial Equipment Merchant Wholesalers
423450	Medical, Dental, and Hospital Equipment and Supplies Merchant Wholesalers
423460	Ophthalmic Goods Merchant Wholesalers
423490	Other Professional Equipment and Supplies Merchant Wholesalers
423510	Metal Service Centers and Other Metal Merchant Wholesalers

NAICS Code	Industry Cluster and NAICS Industry Description
423520	Coal and Other Mineral and Ore Merchant Wholesalers
423610	Electrical Apparatus and Equipment, Wiring Supplies, and Related Equipment Merchant Wholesalers
423620	Electrical and Electronic Appliance, Television, and Radio Set Merchant Wholesalers
423690	Other Electronic Parts and Equipment Merchant Wholesalers
423710	Hardware Merchant Wholesalers
423720	Plumbing and Heating Equipment and Supplies (Hydronics) Merchant Wholesalers
423730	Warm Air Heating and Air-Conditioning Equipment and Supplies Merchant Wholesalers
423740	Refrigeration Equipment and Supplies Merchant Wholesalers
423810	Construction and Mining (except Oil Well) Machinery and Equipment Merchant Wholesalers
423820	Farm and Garden Machinery and Equipment Merchant Wholesalers
423830	Industrial Machinery and Equipment Merchant Wholesalers
423840	Industrial Supplies Merchant Wholesalers
423850	Service Establishment Equipment and Supplies Merchant Wholesalers
423860	Transportation Equipment and Supplies (except Motor Vehicle) Merchant Wholesalers
423910	Sporting and Recreational Goods and Supplies Merchant Wholesalers
423920	Toy and Hobby Goods and Supplies Merchant Wholesalers
423930	Recyclable Material Merchant Wholesalers
423940	Jewelry, Watch, Precious Stone, and Precious Metal Merchant Wholesalers
423990	Other Miscellaneous Durable Goods Merchant Wholesalers
424110	Printing and Writing Paper Merchant Wholesalers
424120	Stationery and Office Supplies Merchant Wholesalers
424130	Industrial and Personal Service Paper Merchant Wholesalers
424210	Drugs and Druggists' Sundries Merchant Wholesalers
424310	Piece Goods, Notions, and Other Dry Goods Merchant Wholesalers
424320	Men's and Boys' Clothing and Furnishings Merchant Wholesalers
424330	Women's, Children's, and Infants' Clothing and Accessories Merchant Wholesalers
424340	Footwear Merchant Wholesalers
424410	General Line Grocery Merchant Wholesalers
424420	Packaged Frozen Food Merchant Wholesalers
424430	Dairy Product (except Dried or Canned) Merchant Wholesalers
424440	Poultry and Poultry Product Merchant Wholesalers
424450	Confectionery Merchant Wholesalers
424460	Fish and Seafood Merchant Wholesalers
424470	Meat and Meat Product Merchant Wholesalers
424480	Fresh Fruit and Vegetable Merchant Wholesalers
424490	Other Grocery and Related Products Merchant Wholesalers
424510	Grain and Field Bean Merchant Wholesalers
424520	Livestock Merchant Wholesalers
424590	Other Farm Product Raw Material Merchant Wholesalers

NAICS Code	Industry Cluster and NAICS Industry Description
424610	Plastics Materials and Basic Forms and Shapes Merchant Wholesalers
424690	Other Chemical and Allied Products Merchant Wholesalers
424710	Petroleum Bulk Stations and Terminals
424720	Petroleum and Petroleum Products Merchant Wholesalers (except Bulk Stations and Terminals)
424810	Beer and Ale Merchant Wholesalers
424820	Wine and Distilled Alcoholic Beverage Merchant Wholesalers
424910	Farm Supplies Merchant Wholesalers
424920	Book, Periodical, and Newspaper Merchant Wholesalers
424930	Flower, Nursery Stock, and Florists' Supplies Merchant Wholesalers
424940	Tobacco and Tobacco Product Merchant Wholesalers
424950	Paint, Varnish, and Supplies Merchant Wholesalers
424990	Other Miscellaneous Nondurable Goods Merchant Wholesalers
425110	Business to Business Electronic Markets
425120	Wholesale Trade Agents and Brokers
484121	General Freight Trucking, Long-Distance, Truckload
484122	General Freight Trucking, Long-Distance, Less Than Truckload
484230	Specialized Freight (except Used Goods) Trucking, Long-Distance
488510	Freight Transportation Arrangement
488991	Packing and Crating
493110	General Warehousing and Storage
493120	Refrigerated Warehousing and Storage
493130	Farm Product Warehousing and Storage
493190	Other Warehousing and Storage
541614	Process, Physical Distribution, and Logistics Consulting Services
561910	Packaging and Labeling Services

Table A-2: High-Skilled, High-Demand Occupations in the SBE Region, 2010–2017

	Occupation	Regional Employment, 2017	Regional Location Quotient, 2017	Job Growth, 2010-17
Management	Purchasing Managers	206	**1.45**	41%
	Industrial Production Managers	896	**2.76**	36%
	General and Operations Managers	5,003	**1.18**	22%
	Architectural and Engineering Managers	287	0.83	21%
	Sales Managers	568	0.79	20%
	Chief Executives	377	0.85	19%
Business/ Financial	Purchasing Agents	942	**1.62**	32%
	Cost Estimators	342	0.82	29%
	Human Resources Specialists	934	0.91	19%
IT	Computer Programmers	419	0.81	22%
	Network, Computer Systems Admins	640	0.87	19%
Engineering	Mechanical Engineers	672	**1.22**	25%
	Industrial Engineers	832	**1.69**	23%
Design/Media	Commercial and Industrial Designers	216	**3.40**	47%
Healthcare	Physical Therapists	278	0.65	30%
	Nurse Practitioners	232	0.78	27%
	Healthcare Social Workers	324	1.00	21%

Note: High-skilled occupations generally require a bachelor's degree or higher for entry. "High-Demand" regional occupations are those that have a sizable base, are growing, and are outpacing overall regional growth. "Specialized" location quotients of 1.2 or greater are highlighted in red font.
Source: TEConomy's analysis of Bureau of Labor Statistics, Occupational Employment Statistics data from EMSI.

Table A-3: Middle-Skilled, High-Demand Occupations in the SBE Region, 2010–2017

	Occupation	Regional Employment, 2017	Regional Location Quotient, 2017	Job Growth, 2010-17
Drafters, Eng. Techs	Mechanical Drafters	236	1.95	31%
	Industrial Engineering Technicians	229	1.86	29%
Sales	Sales Representatives, Wholesale and Manufacturing	3,623	1.34	26%
Office, Admin	Production, Planning, and Expediting Clerks	652	1.04	24%
Construction	Sheet Metal Workers	400	1.53	45%
	Plumbers, Pipefitters, and Steamfitters	1,057	1.30	42%
	Electricians	1,255	1.06	31%
	Carpenters	1,169	0.88	25%
Installation, Maintenance	Recreational Vehicle Service Technicians	634	24.07	43%
	Automotive Body and Related Repairers	403	1.44	43%
	Heating, Air Conditioning, Refrigeration Mechanics & Installers	428	0.73	35%
	Industrial Machinery Mechanics	908	1.39	33%
	Bus and Truck Mechanics and Diesel Engine Specialists	661	1.34	32%
	Electronic Equipment Installers and Repairers, Motor Vehicles	246	11.50	31%
	Installation, Maintenance, and Repair Workers, All Other	209	0.72	27%
	Maintenance and Repair Workers, General	3,581	1.38	23%
	Automotive Service Technicians and Mechanics	1,874	1.51	21%
Transportation	Heavy and Tractor-Trailer Truck Drivers	3,690	1.12	25%

	Occupation	Regional Employment, 2017	Regional Location Quotient, 2017	Job Growth, 2010-17
Production	Fiberglass Laminators and Fabricators	1,543	41.17	80%
	Upholsterers	868	13.81	69%
	Adhesive Bonding Machine Operators and Tenders	329	10.12	65%
	Assemblers and Fabricators, All Other	3,067	6.96	62%
	Painters, Transportation Equipment	1,329	12.44	62%
	Cutting and Slicing Machine Setters, Operators, and Tenders	465	3.80	60%
	Woodworking Machine Setters, Operators, and Tenders, Except Sawing	1,031	7.01	56%
	Computer-Controlled Machine Tool Operators, Metal and Plastic	1,108	3.93	53%
	Team Assemblers	20,162	9.41	51%
	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	701	4.29	50%
	Cabinetmakers and Bench Carpenters	1,283	6.81	49%
	Sawing Machine Setters, Operators, and Tenders, Wood	434	4.44	48%
	Packaging and Filling Machine Operators and Tenders	1,159	1.54	44%
	Mixing and Blending Machine Setters, Operators, and Tenders	425	1.67	42%

Table A-3: Middle-Skilled, High-Demand Occupations in the SBE Region, 2010–2017 (Continued)

	Occupation	Regional Employment, 2017	Regional Location Quotient, 2017	Job Growth, 2010-17
Production	Welders, Cutters, Solderers, and Brazers	2,716	3.78	34%
	Inspectors, Testers, Sorters, Samplers, and Weighers	2,376	2.39	33%
	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	423	3.08	33%
	Heat Treating Equipment Setters, Operators, and Tenders, Metal and Plastic	216	5.81	32%
	Molding, Coremaking, and Casting Machine Setters, Operators, and Tenders, Metal and Plastic	2,636	9.59	31%
	Machinists	1,730	2.35	30%
	Structural Metal Fabricators and Fitters	426	2.88	29%
	Engine and Other Machine Assemblers	276	3.81	28%
	Grinding, Lapping, Polishing, and Buffing Machine Tool Setters, Operators, and Tenders, Metal and Plastic	410	2.95	23%
	Production Workers, All Other	586	1.19	22%
	Multiple Machine Tool Setters, Operators, and Tenders, Metal and Plastic	476	2.12	21%
	Plating and Coating Machine Setters, Operators, and Tenders, Metal and Plastic	295	4.46	21%
	Cutting, Punching, and Press Machine Setters, Operators, and Tenders, Metal and Plastic	1,596	4.42	20%

Note: Middle-skilled occupations generally require significant education, experience, and/or training beyond high school but less than a bachelor's degree for entry. "High-Demand" regional occupations are those that have a sizable base, are growing, and are outpacing overall regional growth. "Specialized" location quotients of 1.2 or greater are highlighted in red font.
Source: TEConomy's analysis of Bureau of Labor Statistics, Occupational Employment Statistics data from EMSI.

SBE Industry Clusters: Summary Data at the Five-County Regional Level

The SBE Region has long been more broadly associated with its Michigan neighbors across the border in a region encompassing 47 smart connected communities in Northern Indiana and Southwestern Michigan. The economy of the SBE Region is closely connected with that of the Southwestern Michigan counties of Berrien and Cass; and the project team has developed an economic analysis that incorporates these counties into a broader, five-county region so as to provide additional regional context.

Detailed industry employment data were examined for the additional two Michigan counties to understand how, if at all, these additional economies alter the industry cluster landscape. In the assessment, the counties did not significantly change how the regional clustering should be shaped. In fact, the industrial composition of the Michigan counties is quite similar, reinforcing and expanding on the SBE Region's cluster strengths in most areas.

In addition to bolstering the clusters of the SBE Region, there has been identified, and reinforced through discussions with Michigan's regional stakeholders, a unique one-company dominant cluster—home appliances—based in Benton Harbor (Berrien County) with Whirlpool's World Headquarters, which includes R&D activities in a technology center, though no longer includes manufacturing operations.

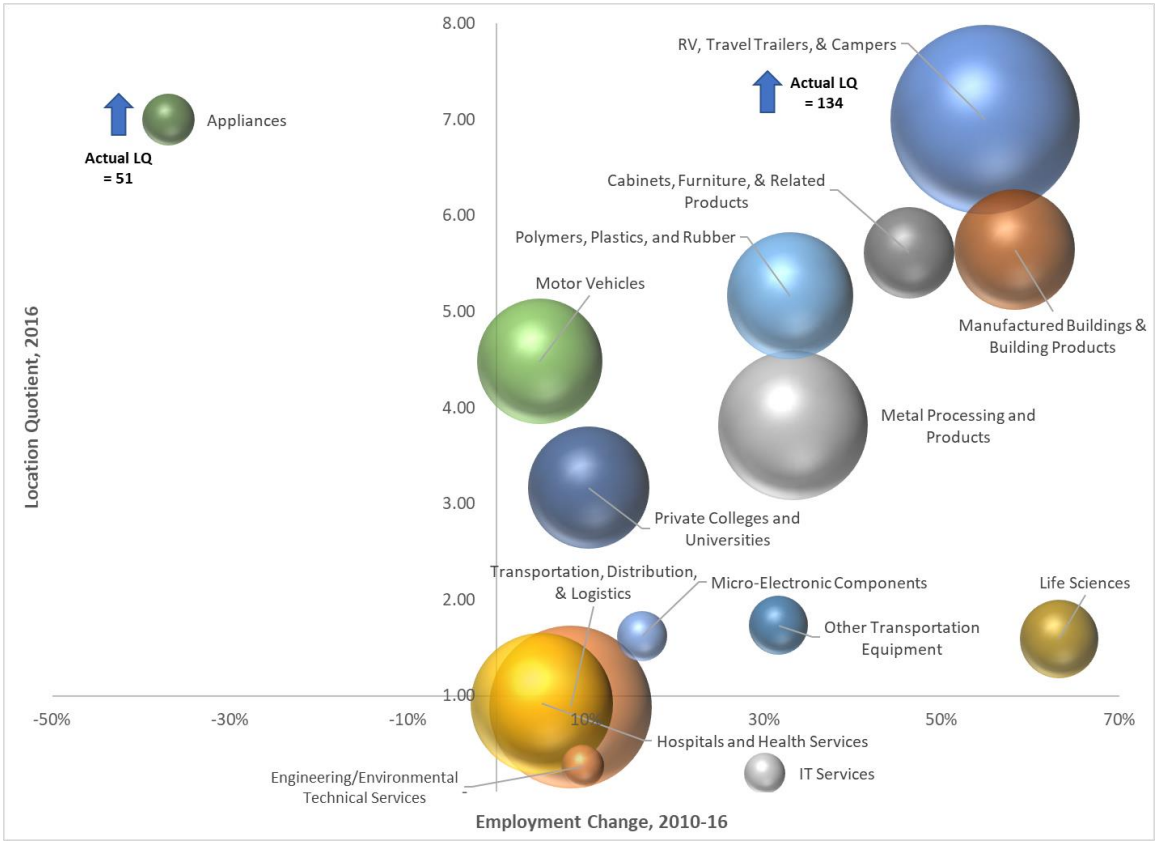
Table A-4 and Figure A-1 profile the industry clusters of the SBE Region, including home appliances, for the five-county region.

Table A-4: Establishment and Employment Overview, SBE Regional Industry Clusters for the Five-County Region

SBE Regional Industry Clusters	Establishments, 2016	Employment, 2016	Location Quotient, 2016	Employment Change, 2010-16
Total Private Sector	**15,163**	**306,498**	**1.00**	**17%**
RV, Travel Trailers, & Campers	71	24,742	133.68	55%
Transportation, Distribution, & Logistics	1,362	18,178	0.88	8%
Metal Processing and Products	430	15,331	3.82	33%
Hospitals and Health Services	88	13,859	0.92	5%
Polymers, Plastics, and Rubber	167	10,924	5.17	33%
Motor Vehicles	114	10,749	4.48	5%
Private Colleges and Universities	13	10,154	3.16	10%
Manufactured Buildings & Building Products	185	9,940	5.64	58%
Cabinets, Furniture, & Related Products	114	5,593	5.61	46%
Life Sciences	44	4,146	1.59	63%
Other Transportation Equipment	16	2,367	1.73	32%
Home Appliances	1	1,803	51.20	-37%
Micro-Electronic Components	23	1,675	1.62	16%
Engineering/Environmental Technical Services	148	1,225	0.26	10%
IT Services	165	1,111	0.19	30%

Source: TEConomy's analysis of Bureau of Labor Statistics, Quarterly Census of Employment and Wages (QCEW) data; enhanced file from IMPLAN.

Figure A-1: Regional Cluster Employment Size, Concentration, and Recent Trends, Five-County SBE Region



Source: TEConomy's analysis of Bureau of Labor Statistics, QCEW data; enhanced file from IMPLAN.