

Tennessee's Downstream Chemicals Cluster

August 2017

By Sally Avery

Director, Center for Economic Research in Tennessee (CERT)
Tennessee Department of Economic and Community Development

INTRODUCTION

This paper provides an examination of Tennessee's downstream chemicals cluster. There are varying definitions of clusters, but at its basic level, "a cluster is a regional concentration of related industries in a particular location... They consist of companies, suppliers, and service providers, as well as government agencies and other institutions that provide specialized training and education, information, research, and technical support."¹

Cluster evaluation is an important component of economic development strategy for a number of reasons. A cluster strategy provides a defined objective to support the growth and successfulness of a group of related industries and other actors. Defining target clusters can provide economic development organizations with a focus for limited resources and a framework by which to support job growth and rising wages in the economy. Where workforce availability and competency is the leading concern for companies across the nation, clusters provide a guiding framework for the higher education and workforce development community to develop strategies that meet the needs of business. A cluster strategy leads to greater communication and feedback amongst cluster stakeholders; which can in turn result in the identification of common barriers and solutions to widespread concerns.

An in-depth review of clusters from the U.S. Cluster Mapping Project revealed a strong presence of several clusters in Tennessee. Downstream chemicals were selected for this project because the cluster demonstrated strong employment and employment concentration in Tennessee, the cluster provides high quality jobs, the growth of which is the vision for the Tennessee Department of Economic and Community Development (TNECD); the cluster has been growing as evidenced by TNECD's portfolio of past company expansion and recruitment projects and the current pipeline of projects; and because the industry demonstrated high exports and foreign direct investment activity in the state.

The objective of this research is to clearly define the cluster and identify the cluster's presence within and across the state.

The paper begins with an overview of Tennessee's downstream chemicals cluster, which is followed by more specific information on each of five sub-clusters including key facts and leading companies. The paper then includes information on Tennessee's downstream chemicals supply chain; chemical product exports; and an analysis of the cluster's staffing patterns (or top occupations) in Tennessee. Lastly, the report provides an overview of challenges, opportunities and advantages facing the downstream chemicals cluster along with recommendations.

Sources:

The following research is an analysis of statistics reported by statistical database Economic Modeling Specialists, Intl. (Emsi): Industry statistics (including employment, job growth, wages, number of business locations, and employment concentration), industry purchasing patterns,

¹ Source: The U.S. Cluster Mapping Project. The U.S. Cluster Mapping Project is a national economic initiative that provides over 50 million open data records on industry clusters and regional business environments in the United States to promote economic growth and national competitiveness. The project is led by Harvard Business School's Institute for Strategy and Competitiveness in partnership with the U.S. Department of Commerce and U.S. Economic Development Administration.

Tennessee’s Downstream Chemicals Cluster

workforce demographics, occupational data (including employment, wages, employment concentration and annual openings), and postsecondary programs and completions.

The Tennessee department of Labor and Workforce Development is the source for Tennessee job postings data from 2017 Q2.

Trade Stats Express from the International Trade Association, U.S. Department of Commerce, is the source for export data.

Analysis of seven IBISWorld industry reports is the source of information on industry trends and leading companies by market share: “Dye and Pigment Manufacturing in the US.” (June 2017); “Paint Manufacturing in the US.” (November 2016); “Adhesives Manufacturing in the US.” (May 2017); “Soap & Cleaning Compound Manufacturing in the US.” (September 2016); “Cosmetic & Beauty Products Manufacturing in the US.” (May 2017); “Explosives Manufacturing in the US.” (October 2016); “Chemical Product Manufacturing in the US.” (June 2017).

Sources for company information include company websites, Hoover’s Dun & Bradstreet and feedback from ECD’s regional business development offices.

Table of Contents

Introduction	2
Downstream Chemical Products: Overview	4
Personal Care and Cleaning Products.....	8
Synthetic Dyes and Pigments	11
Paint, Coating and Adhesive Products	13
Explosives.....	15
Other Chemical Products	18
Supply Chain (Industry Purchases)	20
Exports.....	23
Staffing Patterns.....	24
Advantages and Opportunities Facing Tennessee’s Downstream Chemicals Cluster	29
Challenges facing tennessee’s Downstream Chemicals Cluster	30
Appendix A: Higher Education—Key Programs	33

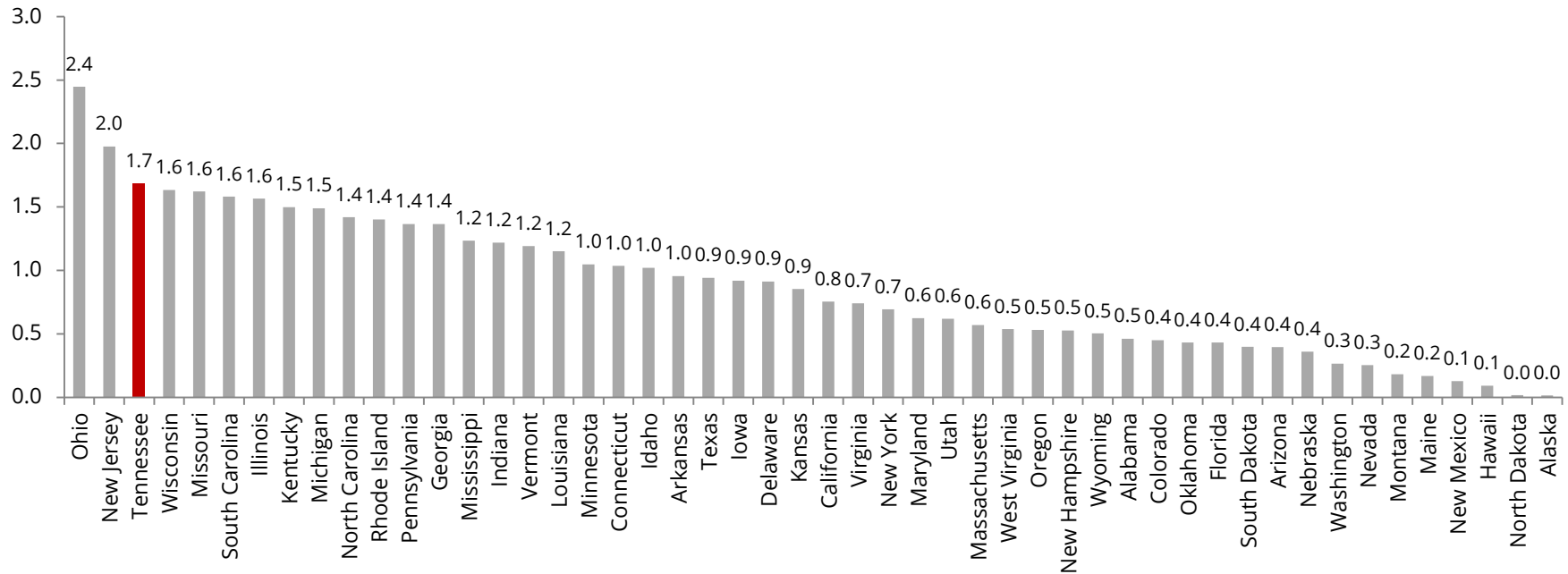
DOWNSTREAM CHEMICAL PRODUCTS: OVERVIEW

Downstream chemicals include a wide variety of products. Tennessee's cluster has been broken down into five sub-clusters: personal care and cleaning products; dyes and pigments; paints, coatings and adhesives; explosives and other chemical products.

The downstream chemicals cluster comprises 8,804 jobs across 164 business locations in Tennessee. Tennessee's employment concentration in the cluster (or the ratio of downstream chemicals employment to total employment) is 70 percent above the national average. This level of downstream chemicals concentration ranks **No. 1 highest in the Southeast and No. 3 highest in the nation.**

Downstream Chemicals Employment Concentration by State (2016)

Location Quotient of 1.0 Equals the National Average Concentration



Source: EMSI 2017.Q2

The cluster has experienced strong employment growth of 5.0 percent over the five years from 2011 to 2016, while nationally the cluster has increased by only 2.1 percent. Tennessee's downstream chemicals job growth exceeded projections by 132 percent. Where projections are based on downstream chemical trends occurring nationally and overall economic trends not specific to the industry – competitive factors

Tennessee's Downstream Chemicals Cluster

inherent to Tennessee's cluster accounts for significant growth. In fact, an estimated 57 percent of Tennessee's downstream chemicals job growth is the result of this competitive effect.²

This cluster of advanced manufacturing industries has a strong economic impact. For every one job created in downstream chemicals businesses, another 2.15 jobs are created in the regional economy.³ This includes 0.63 jobs created in the supplier network as a result of chemical companies' new input purchases (indirect job creation), and an additional 1.53 jobs created in the economy as a result of new earnings and investment. This latter induced job creation occurs as employees spend their paychecks in the region, businesses invest to grow their operations, and government spends more to support the changes. Rising earnings will also accompany job growth. For every new dollar in earnings added to the payrolls of chemical companies, another \$1.42 in earnings will be added to the economy as a result of indirect and induced impacts.

² Competitive effect estimates are based on EMSI's data

³ The source for economic impact estimates is EMSI's input-output model, which incorporates data from the Bureau of Economic Analysis (BEA).

Tennessee's Downstream Chemicals Cluster

Tennessee's Downstream Chemicals Cluster (2016)

NAICS Code	Industry	Employment	Job Growth (2011-2016)	Location Quotient	No. Business Locations	Avg. Annual Wages	Avg. Annual Earnings ⁴	Jobs Multiplier
PERSONAL CARE AND CLEANING PRODUCTS								
325611	Soap and Other Detergents	740	13%	1.37	14	\$74,424	\$94,931	3.81
325612	Polish and Other Sanitation Goods	399	15%	0.84	23	\$59,313	\$74,884	3.17
325613	Surface Active Agents	93	27%	0.99	3	\$58,257	\$74,701	3.54
325620	Cosmetic and Beauty Products	1,943	0%	1.77	16	\$49,257	\$63,109	3.12
SYNTHETIC DYE AND PIGMENT MANUFACTURING								
325130	Synthetic Dyes and Pigments	1,432	3.8%	5.21	11	\$87,290	\$112,016	3.24
PAINT, COATING AND ADHESIVE MANUFACTURING								
325510	Paints and Coatings	538	-19.7%	0.66	24	\$68,075	\$87,360	3.05
325520	Adhesives	406	11.8%	0.93	17	\$73,945	\$94,894	3.15
EXPLOSIVES								
325920	Explosives	956	33.3%	6.74	9	\$69,665	\$89,398	2.51
OTHER CHEMICAL PRODUCTS								
325991	Custom Compounding of Purchased Resins	1,314	50.0%	3.72	15	\$51,008	\$65,450	2.37
325992	Photographic Film, Paper, Plate, and Chemical Products	63	-52.6%	0.26	10	\$36,421	\$46,130	2.07
325998	All Other Miscellaneous Chemical Products and Preparation Manufacturing	920	-24.7%	1.21	22	\$67,180	\$86,195	2.49
TOTAL		8,804	5.0%	1.68	164	\$64,657	\$82,839	3.15

Source: EMSI 2017.Q2

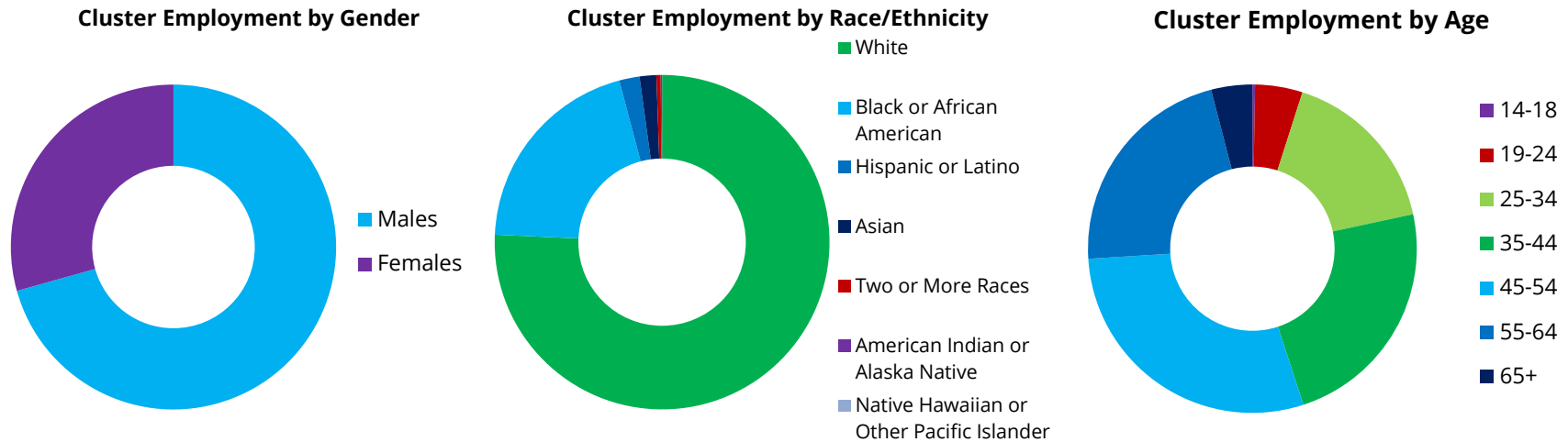
⁴ Total annual earnings include wages, salaries, profits, benefits and other compensation.

Workforce Demographics (2016)

The downstream chemicals workforce of 8,804 jobs is largely male. In 2016, 70.6 percent of the jobs (6,219) were held by males, and only 29.4 percent (2,584) were held by females.⁵ A majority of the workforce is white (75.7 percent, or 6,665 people). 20.2 percent of the workforce is Black or African American, and a very small share of the workforce is Hispanic or Latino (2.0 percent), Asian (1.6 percent), Two or More Races (0.4 percent), or American Indian or Alaska Native (0.1 percent).

A quarter of the downstream chemicals workforce will be reaching retirement age in the next 10 years or is already of retirement age (nearly 2,300 workers are age 55 or older). Retirements of the baby boomer generation may cause significant disruption to the workforce of many industries across the United States. This is a challenge that requires significant attention across the workforce development and employer community. In the "Staffing Patterns" section of this paper, the percentage of workforce nearing retirement age in relevant occupations are outlined.

Workers age 25 to 34 comprise 16.7 percent of the workforce (1,470 people), workers age 35 to 44 comprise 23.3 percent of the workforce (2,055 people), and workers age 45 to 54 comprise 29.0 percent of the workforce (2,556 people).



Source: EMSI 2017.Q2

⁵ Source for workforce demographics data is EMSI, which incorporates data from the Census' Quarterly Workforce Indicators and American Community Survey.

PERSONAL CARE AND CLEANING PRODUCTS (NAICS 3256)

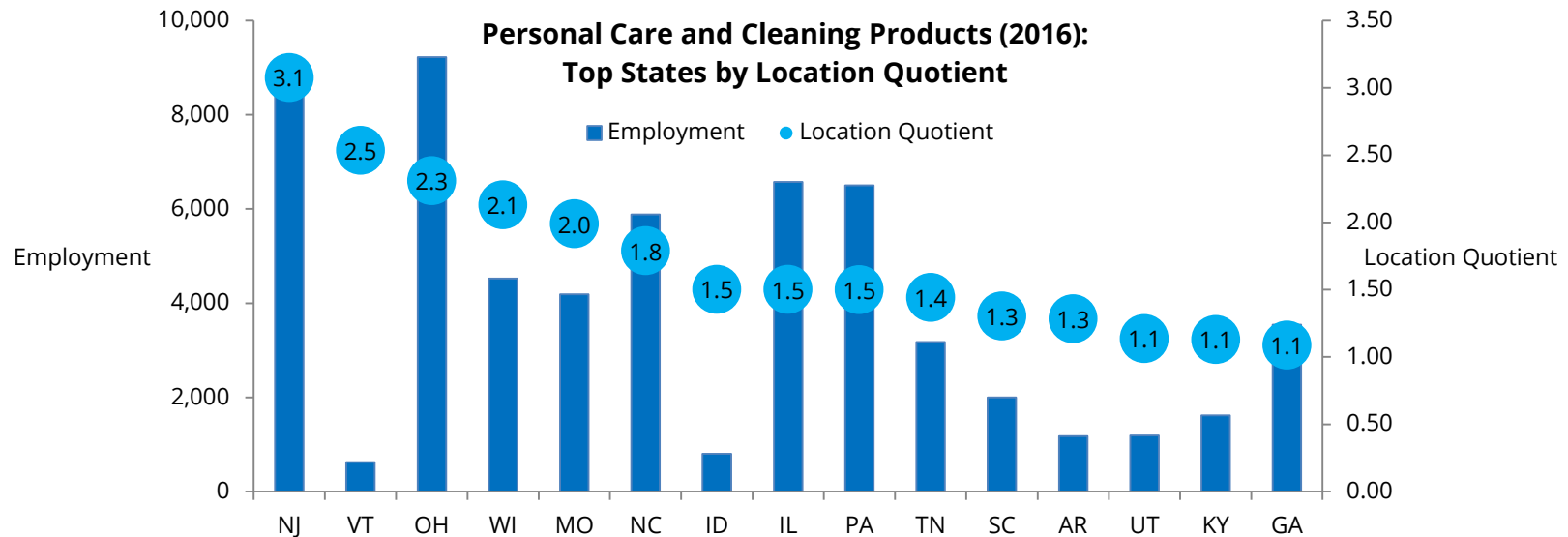
This industry includes businesses which manufacture and package **soaps and cleaning compounds**. This includes a wide range of products; examples include soaps, detergents, toothpastes, disinfectants, floor polishes, bleaches, air fresheners, oven cleaners and surface active agents.

This industry also includes companies manufacture **cosmetic and beauty products**. Processes include preparing, blending, compounding and packaging products such as perfumes, shaving creams, shampoos, lotions, deodorants, baby powders, and all types of makeup products.

Source: North American Industry Classification System (NAICS) definitions from the U.S. Census Bureau,

Key Facts

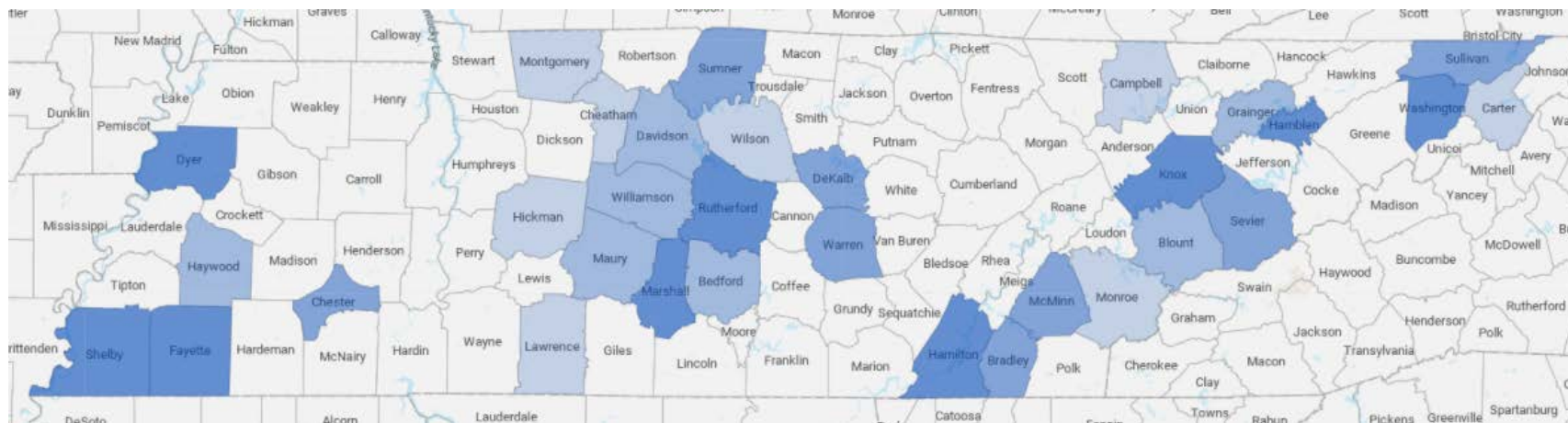
- The industry employs 3,175 people across 56 business locations in Tennessee.
- The state's ratio of personal care and cleaning products employment to total employment is 44 percent above the national average concentration, and ranks 10th highest in the nation.
- 4.9 percent growth in employment over the last five years outpaces national growth for the industry (4.4 percent).
- Average annual wages for this industry in Tennessee (\$56,209) are competitive relative to the national average (\$70,710) while also 20.7 percent above the state's average wage across all industries.



Source: EMSI 2017 Q.2

Personal Care and Cleaning Products Employment by County (2016)

Tennessee's Downstream Chemicals Cluster



Source: EMSI 2017 Q.2

Local Presence & Leading Companies

The top five metropolitan areas by 2016 employment in personal care and cleaning products were New York City (Colgate-Palmolive Company, Estee Lauder and Coty Inc.), Los Angeles, Chicago, Cincinnati (Proctor & Gamble Company), and Philadelphia.

Oxford, NC—where Revlon operates the world's largest cosmetic manufacturing facility with a workforce of approximately 2,400 – has the highest concentration of personal care and cleaning supplies employment of all the nation's MSAs (location quotient of 152.1). Other areas where one significant employer drives a strong industry concentration are **Racine, WI** (S.C. Johnson & Son Inc.); **Cambridge, OH** (Colgate-Palmolive); and **Bowling Green, KY** (Sun Products) which rank No. 2, No. 4 and No. 5 for employment concentration, respectively.

Other areas with a strong industry presence by both employment and concentration include Grand Rapids-Wyoming, MI; St. Louis, MO-IL; Akron, OH; Greensboro-High Point, NC; Elkhart-Goshen, IN; Spartanburg, SC and Lima, OH.

In **Morristown**, the ratio of personal care & cleaning products employment (233) to total employment is 606 percent above the national average. **Colgate-Palmolive Company** operates an 88,000 square foot oral care facility in Morristown where the company manufactures toothpaste. In 2014 the company announced plans to make a \$25 million investment in Morristown, creating 75 new jobs.⁶ Colgate-Palmolive "dominates the oral-care category with a worldwide toothpaste market share of almost 45.0%."⁷ **Team Technologies**, the largest North American producer of toothbrushes, also operates its main plant in Morristown.

⁶ <http://www.tnecd.com/news/128/colgate-palmolive-to-locate-light-manufacturing-operation-in-morristown/>

⁷ "Soap and Cleaning Compounds Manufacturing in the US Industry Report." IBISWorld

Tennessee's Downstream Chemicals Cluster

The Nashville MSA has 10 business locations employing 946 jobs in the industry. The industry's employment concentration in Nashville is 39 percent above the national average. **Vi-Jon Inc.**, which employs approximately 700 people in Smyrna, is one of the nation's longest-running personal care manufacturers. Vi-Jon's product line includes shampoos, soaps, ointments, peroxide, lotion, cleansers, nail polish remover and name brand products such as Germ-X. German-based **Schwan Cosmetics** manufactures cosmetic products in Murfreesboro with a workforce of approximately 300. The grand opening of Schwan's new facility occurred in September 2015—a product of the company's \$40 million investment in the state to consolidate operations previously located in Lewisburg, TN and Piscataway, NJ. **Kyzen Corporation** is another Nashville-area company which produces cleaning agents for electronics manufacturing, advanced packaging and metal finishing applications.

Memphis has 23 business locations employing 1,077 jobs in the personal care & cleaning products industry. The industry's employment in Memphis as a share of total employment is 132 percent above the national average. Employers include hair care products by **Ampro Industries**; soap producers **Bluff City Soap Company**, **Vanguard Soap** and **Valley Products Co.**; and sanitation and cleaning supplies producer **Delta Foremost Chemical Corp.**

Recent business closures in West Tennessee have generated an additional available workforce with experience in personal care and cleaning products industry, presenting an opportunity for the recruitment or expansion of other companies in the industry. In 2016, Dyersburg's employment concentration of the personal care & cleaning products industry ranked 5th highest in the nation and was 2200 percent above the national average concentration. This was driven by **The Sun Products**, which employed 250 people in the production of Sun detergent and Snuggle fabric conditioner, among other products. The Sun Products closed its facility and was acquired by Henkel Corporation in 2016, moving Henkel to the No. 2 leader in the North American laundry care market.⁸ Additionally, **KIK Custom Products** and **Bayer** closed Memphis personal care and cleaning product facilities in 2015. Bayer's acquisition of Merck led to the closure of this Memphis facility which employed a workforce of 300 people in research and development and distribution positions for Coppertone and Dr. Scholl's products; and KIK Custom Products' workforce of 340 produced household cleaning and personal care products.⁹ Meanwhile, Bayer still operates a crop science research and development facility in Memphis and employs approximately 550 people in Cleveland in the production of pharmaceutical products such as Afrin, Claritin, Coppertone and Alka-Seltzer.

Through its home and personal care business segment, **Unilever PLC** is a leading company in this industry with several brands such as Dove, Axe, Suave and Vaseline. While this business segment does not have a presence in Tennessee, Unilever operates a plant in Covington, where a workforce of approximately 700 produces ice cream and frozen novelty items for brands such as Breyers, Fruttare, Klondike and Popsicle.¹⁰

⁸ <http://www.henkel-northamerica.com/brands-and-businesses/laundry-and-home-care/the-sun-products-corporation>

⁹ <https://www.bizjournals.com/memphis/news/2015/05/27/job-fair-today-for-kiks-laid-off-employees.html>

¹⁰ <https://www.unileverusa.com/news/press-releases/2014/unilever-covington-plant-partners-with-dyersburg-state-community-college.html>

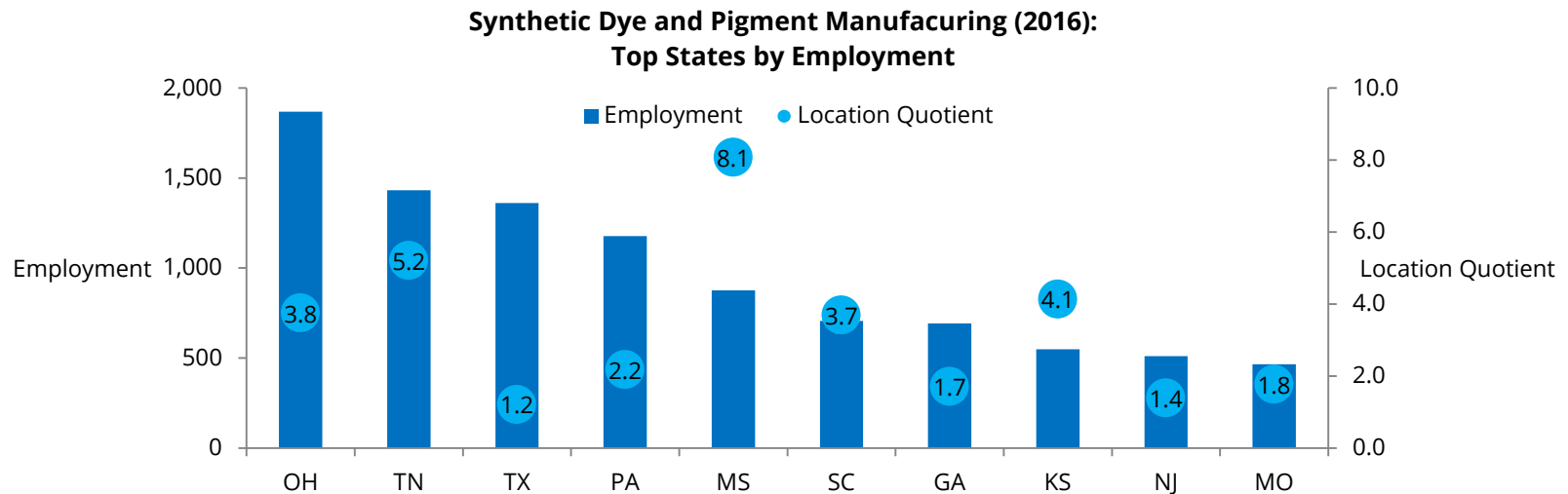
Chattanooga companies operating in the personal care and cleaning product industry include **Bayer** (as mentioned above); **AkzoNobel**, which produces surface active agents; and **Chattem Inc.** A subsidiary of Sanofi, Chattem employs approximately 750 people in Chattanooga in the production of skincare products, shampoo, over the counter pain relievers and many other products.

SYNTHETIC DYES AND PIGMENTS (NAICS 32513)

Companies in this industry manufacture synthetic dyes and pigments. "As a chemical intermediate product, these pigments and dyes are used to impart color to numerous products."¹¹

Key facts

- Tennessee ranks **No. 1 in the Southeast and No. 2 in the nation** for employment in the dye and pigment manufacturing industry, with 1,432 jobs located across the state.
- Tennessee's employment concentration for this industry ranks **No. 3 highest in the nation**, with a ratio of dye and pigment manufacturing employment to total employment that is 421 percent higher than the national average.
- The industry experienced a 3.8 percent rise in jobs over the last five years (2011-2016) in Tennessee, while nationally the industry's employment declined 0.6 percent.
- Companies operating in this industry provide high wages for Tennesseans. The industry's average annual wage in Tennessee (\$87,290) is 88 percent above the state's average wage for all industries.



Source: EMSI 2017 Q.2

¹¹ "Dye and Pigment Manufacturing in the US." (June 2017). IBISWorld.

Synthetic Dye and Pigment Manufacturing Employment by County (2016)



Source: EMSI 2017 Q.2

Local Presence & Leading Companies

The top five locations¹² for dye and pigment employment in the United States are Houston-The Woodlands-Sugarland (Huntsman Corporation), Cincinnati, Philadelphia-Camden-Wilmington (The Chemours Company and Sun Chemical Corporation), Wichita, St. Louis and New York-Newark-Jersey City (BASF Corporation).

The **Knoxville** area ranks No. 11 among 933 MSAs in the nation for employment in synthetic dye and pigment manufacturing, followed by Memphis (No. 12).¹³ **Techmer PM**, based in Clinton, designs and produces colorants and additives for the plastics and fiber industries; and also offers design and compounding of specialty engineering plastics. The company operates 6 production facilities in North America—the largest of which is in Clinton.

The Chemours Company is a new company, spun off from DuPont's performance chemicals business in 2015, and has since become a Fortune 500 company. Chemours maintains 18 percent of the dye and pigment industry's market share, due to its titanium dioxide pigment production.¹⁴ The company employs approximately 700 people at its 1500 acre site in **New Johnsonville**; this plant produces a quarter of the nation's titanium dioxide. The company also operates the world's largest sodium cyanide plant in **Memphis**.

¹² Source: EMSI 2017 Q.2

¹³ Source: EMSI 2017 Q.2

¹⁴ IBISWorld

BASF Corporation, maintaining 23 percent of the industry's market share,¹⁵ has facilities in **Chattanooga** and **Sparta**. BASF is the second largest producer and marketer of chemicals and related products in North America. The company's Dispersions, Pigments, Resins and Additives business segment produces raw materials for paints and coatings formulations—including architectural coatings, automotive and commercial vehicle coatings or industrial coatings—and supplies coatings to all major North American carmakers. Two Chattanooga facilities produce polymer dispersions used in coatings, adhesives and other products; and the Sparta operation produces colored specialty resins for use in automotive, power tool, furniture and other applications.

Also located within the greater Chattanooga MSA, **Primex Color, Compounding and Additives** (formerly known as O'Neil Color and Compounding) is located in Jasper. Primex Color produces specialty compounds, color concentrates and additive master batches for the plastics sector. The company expanded its facilities in 2011 and 2016. **Sofix Corporation** produces color formers for carbonless and thermal paper, which is used for receipts, labels, transportation tickets and other applications. Positioned on 23 acres, Sofix became the first U.S. Customs foreign trade zone in the Chattanooga area and exports three quarters of its products abroad.

Other Tennessee companies in the dye and pigment industry include **Colortech, Inc.**, which produces color and additive concentrates for the plastics industry with a workforce of approximately 200 people in **Morristown**; **Prime Colorants**, a division of A. Schulman which produces custom colors and additives in **Franklin**; and **American Colors, Inc.** which produces pigment dispersions and intermediates in **Lebanon** and **Gallatin**.

PAINT, COATING AND ADHESIVE PRODUCTS (NAICS 3255)

Companies within this industry mix pigments, solvents and binders into **paints and other coatings**. Other coatings include stains, varnishes, lacquers, enamels, shellacs, and water-repellent coatings for concrete and masonry. This industry also includes producers of allied paint products such as putties, paint and varnish removers and paint brush cleaners.

The **adhesives** component of this industry encompasses businesses which manufacture adhesives, glues and caulking compounds.

Key Facts

- There are 944 paint, coating and adhesive jobs in Tennessee across 40 business establishments.
- Over the past five years, employment has increased in the adhesives industry (11.8 percent) and declined in the paint and coating industry (-19.7 percent).
- Average annual wages for this industry in Tennessee (\$70,600) are competitive relative to the national average (\$72,573) while also 52 percent above the state's average wage across all industries.

¹⁵ IBISWorld

Paint, Coating and Adhesive Manufacturing Employment by County (2016)



Source: EMSI 2017 Q.2

Local Presence & Leading Companies

The top five MSAs by industry employment in 2016 were Chicago, Cleveland (Sherwin-Williams Co.), Detroit-Warren-Dearborn (Masco Corp.), Los Angeles, Dallas and New York-Newark-Jersey City (Benjamin Moore & Co.). The top five places by employment concentration were Gainesville, TX; Rolla, MO; Marshall, TX; Fernley, NV; and Americus, GA.¹⁶

Employment concentration in paints, coatings and adhesives exceeds the national average in **Memphis** by 70 percent. Within the 12-state Southeast region, Memphis ranks the No. 5 location for industry employment—after Atlanta, Charlotte, Greensboro and Louisville.¹⁷ German-based **Henkel Company**, which is one of the leading companies in the adhesives business by market share, employs approximately 200 people at its Memphis adhesive technologies facility. Henkel has three business segments: adhesive technologies, beauty care and laundry and home care. The adhesive technologies division generates 50 percent of the company's revenues, with brands including Bonderite, Loctite, LePage, Bull Glue and many others.¹⁸ Memphis-based **W.M. Barr & Company** manufactures paint removers, solvents, adhesion and other products. The company employs approximately 250 people in Memphis and in 2016 announced expansion plans that would allow the company to expand manufacturing space on President's Island and re-shore production operations from China. Memphis area companies also include paint-producer **Farrell-Calhoun Paints** and **Koppers Performance Chemicals** which manufactures wood preservatives in Millington.

¹⁶ Source: EMSI 2017 Q.2

¹⁷ Source: EMSI 2017 Q.2

¹⁸ Adhesives Manufacturing in the US." (May 2017). IBISWorld.

Tennessee's Downstream Chemicals Cluster

A high share (43 percent) of Tennessee's paint, coating and adhesive companies are located in the **Nashville-Davidson--Murfreesboro—Franklin MSA**. Within the Southeastern states, Nashville ranks the No. 6 city by number of business establishments in this industry (followed by Memphis, No. 7). Nashville companies include **GCP Technologies**, which produces waterproofing solutions in Mount Pleasant and earlier this year announced expansion plans for its facility,¹⁹ and coatings producer **John L. Armitage & Co.** in Gallatin. **AkzoNobel** operates paint and coating facilities in Nashville and Alcoa, announcing plans for a \$10 million expansion of its Nashville facility in January 2017.²⁰

Tennessee has a strong presence of industry leaders. **3M Company**, based in Minnesota and a leading company by market share in the adhesives industry, has multiple facilities in Tennessee. In December 2014, 3M announced its decision to locate in Clinton—a \$135 million investment with 100 new job commitments.²¹ In 2011, 3M made the decision to locate an adhesives facility in Brentwood, and also purchased DuPont's advanced composite technology facility in Old Hickory. **PPG Industries** has industrial coatings facilities in Lebanon and Memphis. PPG's industrial coatings business produces coatings for a variety of products ranging from appliances construction equipment and automotive parts. **Valspar Corporation**, purchased in 2017 by Sherwin-Williams and a leading name brand of paint products, has a manufacturing facility in Chattanooga.

With 7,000 employees across the globe, **PolyOne Corporation** has a variety of products across five business segments. The company has manufacturing facilities in **Clinton, Dyersburg** and **Vonore** as well as a distribution center in Dyersburg. The company's color, additives and inks business unit produces color and additive concentrates in solid and liquid form.

EXPLOSIVES (NAICS 325920)

This sub-cluster encompasses companies which manufacture explosives, including dynamite and gun powder.

Key Facts

- Tennessee ranks **No. 2 in the nation** for employment (956 jobs) and employment concentration (574 percent above the national average) in explosives manufacturing.
- The industry experienced job growth of 33.3 percent in Tennessee over the last five years (2011-2016), while nationally the industry saw a 3.0 percent *decline* in employment. Tennessee is one of only nine states to experience a net gain in explosives manufacturing employment over this time period.
- Average annual wages for this industry in Tennessee (\$69,665) are competitive relative to the national average (\$72,333) and 50 percent above the state's average wage across all industries.

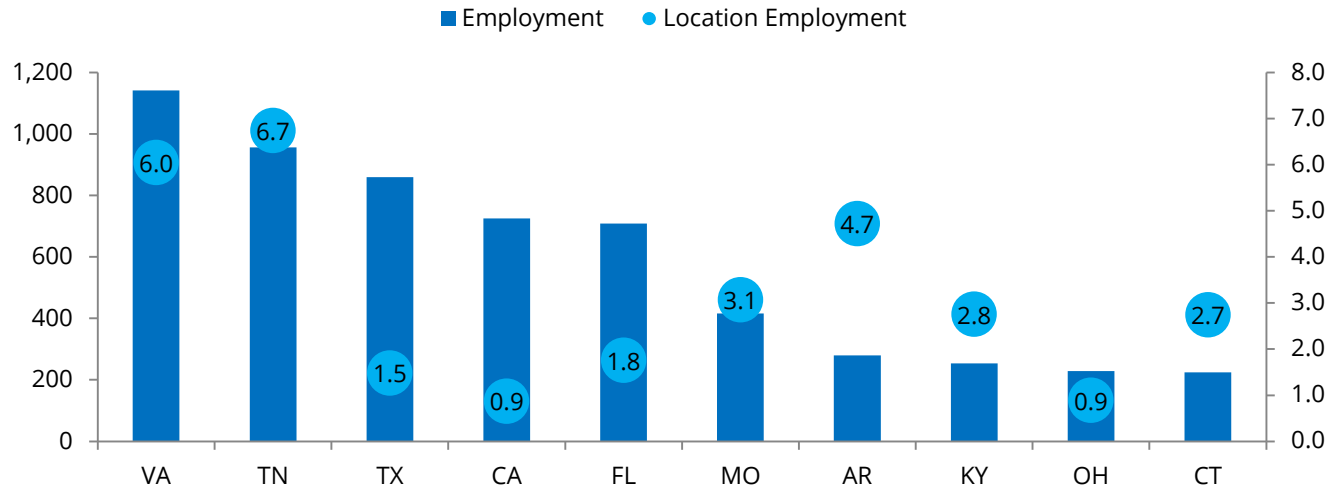
¹⁹ <https://globenewswire.com/news-release/2017/05/23/995425/0/en/GCP-Applied-Technologies-Expands-Production-Capacity-in-Tennessee.html>

²⁰ <http://www.tnecd.com/news/376/akzonobel-to-expand-in-davidson-county/>

²¹ <http://www.tnecd.com/news/149/governor-haslam-commissioner-hagerty-announce-3m-company-to-locate-new-manufacturing-facility-in-clinton/>

Tennessee's Downstream Chemicals Cluster

**Explosives Manufacturing (2016):
Top States by Employment**



Source: EMSI 2017 Q.2

Explosives Manufacturing by County (2016)



Source: EMSI 2017 Q.2

Local Presence & Leading Companies

The top locations for explosives manufacturing employment in 2016 were Blacksburg-Christiansburg-Radford, VA; Dallas-Fort Worth-Arlington, TX; Tallahassee, FL; Kingsport-Bristol-Bristol, TN-VA; Joplin, MO; and Knoxville, TN.

Kingsport is the No. 4 location in the U.S. for explosives manufacturing employment, and No. 7 for employment concentration in the industry. **BAE Systems Ordnance Systems Inc.** employs approximately 525 employees in Kingsport. The company is a recognized leader in partnering at government-owned contractor-operated facilities and has been awarded for its commitment to munitions innovation and plant safety. BAE has been the operating contractor for the **Holston Army Ammunition Plant** for the past 12 years. Holston Army Ammunition Plant is a major supplier of explosive materials to the U.S. Department of Defense.

The **Nashville-Davidson--Murfreesboro—Franklin MSA** ranks No. 13 by industry employment, and has an explosives employment concentration that is 195 percent above the national average. **Accurate Energetic Systems, Inc.** manufactures bulk and fabricated explosives and specialty products for the military, aerospace and commercial markets. The company employs approximately 125 employees in Hickman County.

MAXAM and **Austin Powder** are additional explosives producers with Tennessee operations. Austin Powder manufactures industrial explosives and accessories for the quarrying, mining, construction and oil and gas industries, and maintains 9.3 percent of the explosive industry's market share; MAXAM maintains 5 percent market share.²²

²² "Explosives Manufacturing in the US." (October 2016). IBISWorld.

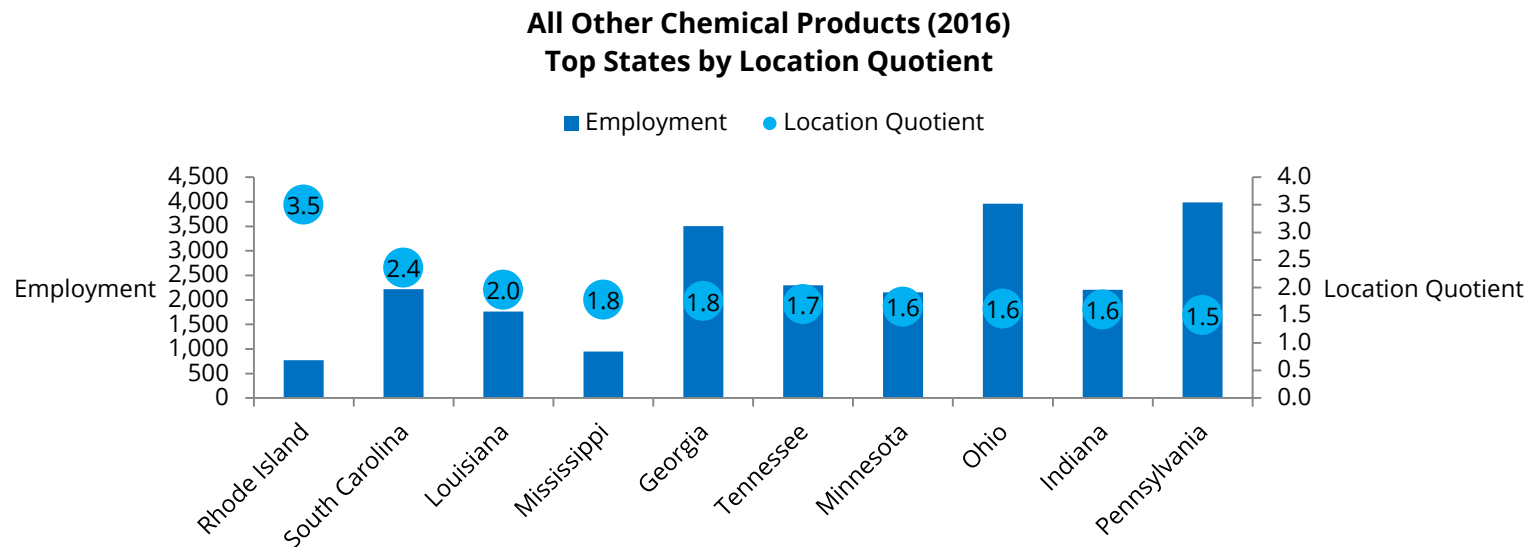
OTHER CHEMICAL PRODUCTS (NAICS 32599)

This industry comprises a wide variety of chemical products:

- **Compound (mix and blend) plastic resins** or reformulate plastic resins from recycled plastics products;
- Produce **photographic products** such as motion picture film, photosensitized paper, printer toners and toner cartridges, and photographic chemicals;
- Other miscellaneous chemical products such as writing inks, flares, charcoal, synthetic sweeteners and other sugar substitutes, swimming pool chemical preparations, lighter fluids, and antifreeze preparations.

Key Facts

- The industry accounts for 2,300 jobs across 47 business locations in Tennessee.
- The state's ratio of industry employment to total employment 70 percent above the national average, which makes Tennessee's employment concentration sixth highest in the nation.
- In the custom compounding of purchased resins line of business, Tennessee ranks No. 1 in the Southeast and No. 3 in the nation for both number of employees (1,314) and employment concentration.
- The industry's employment increased 2.9 percent in Tennessee over the last five years, while declining nationally by 4.5 percent.
- Average annual wages for this industry in Tennessee (\$57,084) are competitive relative to the national average (\$68,526), and 23 percent above the state's average wage for all industries.



Source: EMSI 2017 Q.2

Other Chemical Products Manufacturing Employment by County (2016)



Source: EMSI 2017.Q2

Local Presence & Leading Companies

The top five locations (by industry employment) are Houston-The Woodlands-Sugar Land, Chicago-Naperville-Elgin, Rochester, New York-Newark-Jersey City (Eastman Kodak Company and FUJIFILM Holdings Corporation), and Atlanta-Sandy Springs-Roswell.

Brownsville ranks the No. 1 location out of 933 MSAs for employment concentration in this sub-cluster. This is driven by custom compounder **Teknor Apex**, which employs approximately 600 people at its chemical manufacturing plant in Brownsville. The company has been on a growth trajectory, with an expansion in 2016 and an additional expansion involving the construction of a distribution center in 2017.

Following Brownsville, the top locations for employment concentration include Greenwood, SC (FUJIFILM Manufacturing USA); Hinesville, GA (SNF); Marshall, TX; Sanford, NC; and Winona, MN (RTP). **FUJIFILM Hunt Chemicals** operated a photographic and other specialty chemicals plant in **Dayton, TN** which employed more than 200 people. Until the plant's closure in 2016, Dayton ranked No. 7 in the nation for employment concentration in this industry.

Employment concentration is also high in **Dyersburg**, where businesses such as **HEXPOL Compounding** and **Colonial Diversified Polymers** have chemical manufacturing locations.

PolyOne Corporation, also mentioned within the paint and coatings sub-cluster, has four locations across the state. Industry-relevant products include development of polymer formulations using resins, as well as resins and polymer distribution. The company's specialty inks products also fall within this sub-cluster.

Nashville is also home to companies such as **Advanced Composites, Inc.**, which produces TPO compounds for the automotive industry.

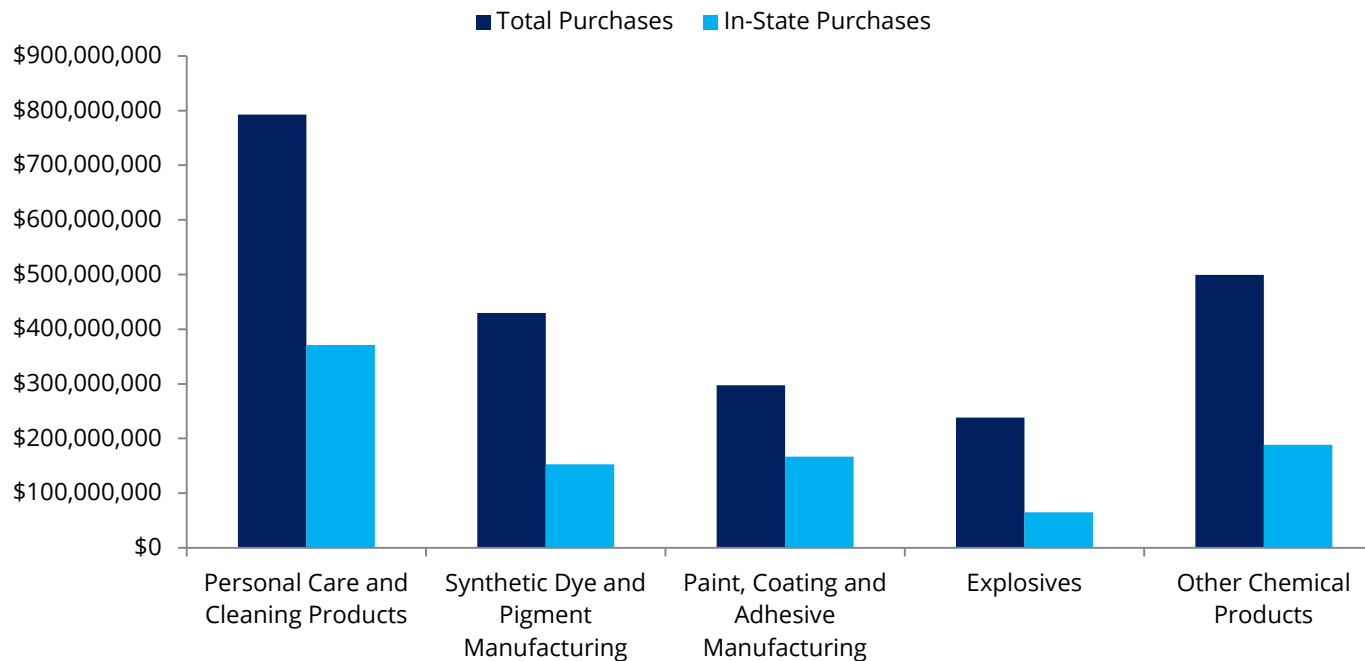
SUPPLY CHAIN (INDUSTRY PURCHASES)

The downstream chemicals cluster has a variety of industries within its supply chain. This section highlights industries which comprise a significant share of the cluster's purchases, as well as the percentage of the cluster's demand which is met by in-state suppliers.

Tennessee's downstream chemicals cluster made purchases totaling \$2.26 billion in 2016. Companies within the personal care and cleaning products sub-cluster accounted for 35.1 percent of these purchases (\$792.8 million); followed by the other chemical products sub-cluster (22.1 percent of purchases, or \$499.5 million); synthetic dye and pigment industry (19.0 percent of purchases, or \$429.5 million); producers of paints, coatings and adhesives (13.2 percent of purchases, or \$297.6 million); and explosives producers (10.6 percent of purchases, or \$238.2 million).

Approximately 42 percent of the cluster's 2016 purchases were made in-state (\$944.5 million). The share of in-state purchases to total purchases was highest for the paints, coatings and adhesives industry (56.2 percent), and lowest for the explosives industry (27.2 percent). Tennessee companies within the personal care and cleaning products industry had the greatest level of in-state purchases, totaling \$371.0 million.

Purchases made by Tennessee's Downstream Chemical Companies (2016)



Tennessee's Downstream Chemicals Cluster

Manufacturers of **plastics material and resins** are top suppliers for downstream chemicals, with sales to Tennessee's cluster totaling \$114.7 million in 2016. Plastics material and resins are primary inputs for the paints, coatings and adhesives industry; the explosives industry; and the other chemical products industry. Approximately 75 percent of this demand is met in-state for the paint, coating and adhesives sub-cluster; however only 18.9 percent of this demand is met in-state for the explosives industry.

Suppliers to Tennessee's downstream chemicals cluster also include producers of **plastic bottles** and **other plastics products**. In 2016 Tennessee's cluster purchased \$37.5 million and \$39.3 million from these industries, respectively. About 40 percent of this demand is met by Tennessee suppliers.

Another leading industry which supplies all five sub-clusters is the **All Other Basic Organic Chemical Manufacturing** industry. Tennessee's downstream chemicals cluster made purchases from this industry totaling \$107.4 million in 2016—of which 30.4 percent was met through in-state suppliers.

Companies within the industry make significant purchases from one another. Downstream chemicals demand for **synthetic dyes and pigments** totaled \$26.3 million in 2016—and 88.2 percent of this demand was met through in-state suppliers. Tennessee producers of paints, coatings and adhesives are a significant consumer of synthetic dyes and pigments, and 93 percent of this demand is met in-state.

Another significant supplier for the cluster are companies which manufacture cardboard boxes, cartons and other related products typically used for shipping. In Tennessee, downstream chemical purchases of **corrugated and solid fiber boxes** totaled \$43.3 million in 2016 (41.9 percent was met in-state), and purchases of **folding paperboard boxes** totaled \$12.3 million (69.8 percent of which was met in-state).

Mining industries represent a significant share of the synthetic dye and pigment supply chain. Tennessee companies operating in this industry made significant purchases from the following mining industries: **gold ore mining** (\$34.9 million), **copper ore and nickel ore mining** (\$34.5 million), **iron ore mining** (\$8.3 million), **construction sand and gravel mining** (\$6.3 million), **silver ore mining** (\$2.2 million), and **all other metal ore mining** (6.1 million). More three-quarters of the industry's demand for lead and zinc ore mining was met in-state (78.6 percent). Zinc Oxide (Dickson) and U.S. Zinc (Clarksville and Millington) produce zinc oxide for the paint and coatings industry, among other customers. U.S. Zinc is the largest provider of zinc oxide in the world, and its two Tennessee plants have a combined capacity of 78,000 metric tons per year. Just over a quarter of the industry's demand for copper ore and nickel ore is met through in-state suppliers, as is one third of the industry's demand for construction sand and gravel mining. The other mining demand is met through suppliers located outside of the state of Tennessee.

These and other industries representing a large share of the cluster's supply chain are available in the table below.

Tennessee's Downstream Chemicals Cluster

NAICS Code	Downstream chemicals purchases from:	Personal Care and Cleaning Products	Synthetic Dye and Pigments	Paints, Coatings and Adhesives	Explosives	Other Chemical Products	Cluster Total	% of Purchases Made In-Region
	All Industries	\$792,830,402	\$429,497,428	\$297,610,746	\$238,206,896	\$499,513,958	\$2,257,659,430	41.8%
551114	Corporate, Subsidiary, and Regional Managing Offices	\$196,234,694	\$74,552,048	\$47,919,097	\$55,187,168	\$115,726,100	\$489,619,106	44.5%
325211	Plastics Material and Resin Manufacturing	\$3,396,344	\$1,308,933	\$36,385,104	\$23,791,809	\$49,890,728	\$114,772,918	47.4%
325199	All Other Basic Organic Chemical Manufacturing	\$37,485,980	\$17,465,181	\$22,034,221	\$9,834,801	\$20,623,338	\$107,443,522	30.4%
325110	Petrochemical Manufacturing	\$5,412,472	\$2,388,607	\$9,448,387	\$13,888,024	\$29,122,784	\$60,260,275	11.4%
325180	Other Basic Inorganic Chemical Manufacturing	\$14,875,566	\$8,575,687	\$3,386,888	\$8,768,554	\$18,387,404	\$53,994,098	42.7%
533110	Lessors of Nonfinancial Intangible Assets (except Copyrighted Works)	\$7,047,889	\$15,500,117	\$8,684,549	\$5,426,005	\$11,378,182	\$48,036,742	36.3%
324110	Petroleum Refineries	\$5,398,887	\$22,672,036	\$5,108,101	\$4,360,823	\$9,144,554	\$46,684,401	20.3%
322211	Corrugated and Solid Fiber Box Manufacturing	\$25,896,966	\$2,773,346	\$4,094,954	\$3,386,941	\$7,102,360	\$43,254,566	41.9%
326199	All Other Plastics Product Manufacturing	\$31,766,770	\$405,046	\$4,026,752	\$1,009,227	\$2,116,324	\$39,324,118	41.2%
326160	Plastics Bottle Manufacturing	\$29,745,107	\$950	\$5,570,854	\$696,234	\$1,459,988	\$37,473,133	40.3%
425120	Wholesale Trade Agents and Brokers	\$17,147,242	\$5,077,527	\$3,927,150	\$3,626,920	\$7,605,574	\$37,384,414	17.6%
212221	Gold Ore Mining	\$1	\$34,854,554	\$1,279,888	\$315,904	\$662,443	\$37,112,790	0.0%
212234	Copper Ore and Nickel Ore Mining	\$1	\$34,542,065	\$379,699	\$27,286	\$57,217	\$35,006,268	27.3%
325998	All Other Miscellaneous Chemical Product and Preparation Manufacturing	\$3,898,806	\$2,099,769	\$964,363	\$6,458,083	\$13,542,484	\$26,963,504	36.2%
325130	Synthetic Dye and Pigment Manufacturing	\$2,104,611	\$2,959,106	\$14,149,144	\$2,293,952	\$4,810,376	\$26,317,188	88.2%
325193	Ethyl Alcohol Manufacturing	\$8,745,660	\$4,074,737	\$5,140,698	\$2,294,516	\$4,811,528	\$25,067,138	5.1%
482110	Rail transportation	\$5,079,282	\$6,757,234	\$4,167,684	\$2,827,083	\$5,928,325	\$24,759,609	32.6%
325611	Soap and Other Detergent Manufacturing	\$23,997,170	\$45,985	\$100,413	\$180,845	\$379,228	\$24,703,641	70.1%
551112	Offices of Other Holding Companies	\$9,693,806	\$3,682,792	\$2,367,157	\$2,726,183	\$5,716,766	\$24,186,704	30.7%
325612	Polish and Other Sanitation Good Manufacturing	\$21,135,314	\$40,501	\$88,438	\$159,278	\$334,002	\$21,757,534	50.2%
484121	General Freight Trucking, Long-Distance, Truckload	\$5,630,410	\$5,133,161	\$2,354,012	\$1,548,094	\$3,246,303	\$17,911,980	75.4%
332710	Machine Shops	\$8,614,858	\$2,849,087	\$1,976,977	\$1,267,438	\$2,657,787	\$17,366,147	31.7%
325520	Adhesive Manufacturing	\$2,387,677	\$1,738,629	\$1,647,660	\$2,651,344	\$5,559,810	\$13,985,121	43.1%

Tennessee's Downstream Chemicals Cluster

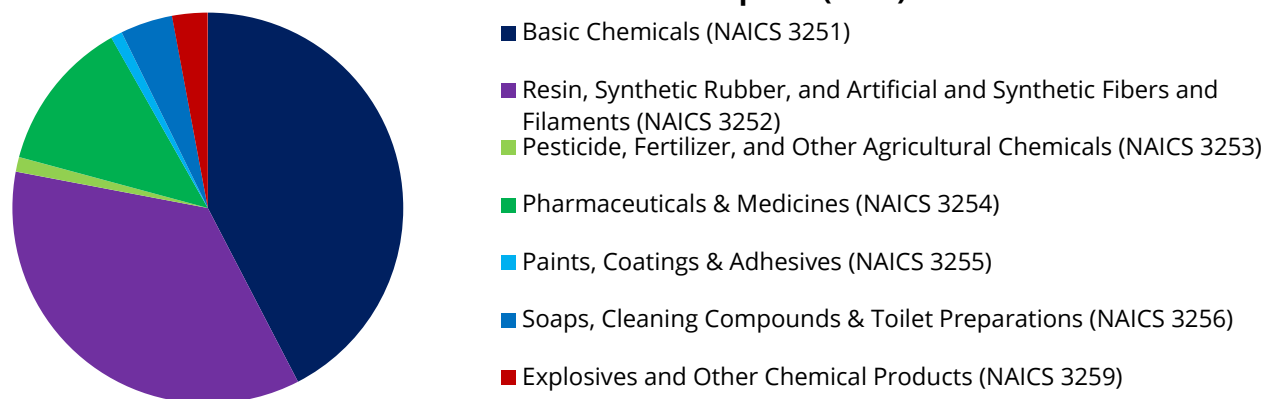
NAICS Code	Downstream chemicals purchases from:	Personal Care and Cleaning Products	Synthetic Dye and Pigments	Paints, Coatings and Adhesives	Explosives	Other Chemical Products	Cluster Total	% of Purchases Made In-Region
311224	Soybean and Other Oilseed Processing	\$7,517,697	\$19,304	\$1,277,333	\$1,291,315	\$2,707,858	\$12,813,507	50.5%
325620	Toilet Preparation Manufacturing	\$12,628,144	\$10,242	\$13,557	\$22,725	\$47,653	\$12,722,321	77.5%
541110	Offices of Lawyers	\$4,855,544	\$2,328,845	\$1,367,931	\$1,318,700	\$2,765,288	\$12,636,308	43.1%
211111	Crude Petroleum and Natural Gas Extraction	\$1,550,117	\$6,252,078	\$1,094,365	\$1,188,701	\$2,492,681	\$12,577,942	0.6%
327992	Ground or Treated Mineral and Earth Manufacturing	\$4,586	\$52,288	\$6,885,894	\$1,806,960	\$3,789,152	\$12,538,881	83.9%
322212	Folding Paperboard Box Manufacturing	\$7,365,836	\$788,817	\$1,164,719	\$963,344	\$2,020,116	\$12,302,832	69.8%
334413	Semiconductor and Related Device Manufacturing	\$5,034,423	\$2,511,071	\$1,698,715	\$860,169	\$1,803,758	\$11,908,135	0.2%
	All Other industries	\$288,178,544	\$168,037,684	\$98,906,042	\$78,028,472	\$163,623,845	\$796,774,586	46.8%

Source: EMSI 2017.Q2

EXPORTS

Tennessee exports in 2016 totaled \$31.4 billion. Chemical products accounted for \$4.2 billion (or 13.4 percent) of the state's exports that year. The top five countries importing Tennessee chemical products were China (\$677.1 million), Canada (\$505.3 million), Mexico (\$491.2 million), the Netherlands (\$430.0 million) and South Korea (\$240.4 million). Downstream chemical products accounted for only a portion of these exports. A breakdown of all chemical product exports is provided below.

Tennessee Chemical Product Exports (2016)



Tennessee's Downstream Chemicals Cluster

Exports of Tennessee soap, cleaning compounds and toiletries totaled \$181.8 million in 2016, accounting for 4.3 percent of Tennessee chemical product exports. Exports of soaps and cleaning products rose from \$154.8 million in 2011 to \$220.7 million in 2013, however have declined over the last two years. This has been the trend of all Tennessee chemical product exports, which rose from \$4.6 billion in 2011 to \$5.0 billion in 2014, and have since been declining. Soaps and cleaning products account for 4.3 percent of Tennessee chemical product exports; this share has remained level over the last three years following significant growth from 3.4 percent in 2011. The top countries importing these Tennessee products last year were Canada (\$68.9 million), Mexico (\$17.3 million), France (\$14.8 million), Brazil (\$7.6 million) and China (\$6.8 million).

Exports of Tennessee explosives and other chemical products totaled \$123.8 million in 2016. This industry's share of total chemical product exports has increased steadily since 2013 from 1.4 percent to 2.9 percent in 2016. The top countries importing these Tennessee products last year were China (\$21.2 million), Japan (\$18.7 million), Canada (\$14.2 million), the Netherlands (\$11.9 million) and Mexico (\$9.0 million).

Tennessee exports of paint, coating and adhesives totaled \$40.0 million in 2016. This industry's share of total chemical product exports has been rising since 2011 from 0.5 percent of chemical product exports to 0.9 percent in 2016. The top countries importing these Tennessee products last year were Mexico (\$16.1 million), Canada (\$8.8 million), Germany (\$4.3 million), China (\$1.3 million) and the UK (\$1.2 million).

Exports of synthetic dye and pigment products cannot be identified with the data available, because they fall within the larger basic chemical manufacturing industry. Exports of basic chemicals totaled \$1.8 billion in 2016. In addition to synthetic dye and pigments, this industry also captures petrochemical manufacturing, industrial gas manufacturing, and other basic organic and inorganic chemical manufacturing.

Source: Analysis of data from Trade Stats Express, a tool provided by the International Trade Association, U.S. Department of Commerce.

STAFFING PATTERNS

The top 50 job classifications which comprise downstream chemical companies' workforce are provided in the table below.²³ The table, in which occupations are organized by Standard Occupational Classification (SOC) code,²⁴ provides 2016 statistics on each occupation's total quotient employment across all industries Tennessee, change in employment over the last five years, employment concentration (or location quotient),²⁵ and median hourly earnings.

²³ Occupations were determined through analysis of the staffing patterns for each individual sub-cluster in Tennessee. Occupations with very low employment and a lack of presence in multiple sub-clusters were excluded from the table.

²⁴ The classification architecture for occupations used by the Bureau of Labor Statistics.

²⁵ Location quotient compares an occupation's employment as a share of total Tennessee employment (or employment concentration) relative to the occupation's employment as a share of total employment in the nation. Where location quotient is greater than 1.0, Tennessee has an above-average

Tennessee's Downstream Chemicals Cluster

The occupation which comprises the greatest share of Tennessee's downstream chemicals workforce is **Mixing and Blending Machine Setters, Operators, and Tenders** (10.1 percent of the overall downstream chemicals workforce). Responsibilities of this position are to manage "machines to mix or blend materials, such as chemicals, tobacco, liquids, color pigments, or explosive ingredients."²⁶ **Packaging and Filling Machine Operators and Tenders** comprise 7.3 percent of Tennessee's downstream chemicals workforce. This position is responsible for managing machines "to prepare industrial or consumer products for storage or shipment." **Team Assemblers**, which comprise 5.9 percent of Tennessee's downstream chemicals workforce, "work as part of a team [to] assemble an entire product or component of a product. Team assemblers can perform all tasks conducted by the team in the assembly process and rotate through all or most of them rather than being assigned to a specific task on a permanent basis."²⁷ [Team assemblers] may participate in making management decisions affecting the work. [This job classification] includes team leaders who work as part of the team." Lastly, **Chemical Equipment Operators and Tenders**, comprising 4.0 percent of Tennessee's downstream chemicals workforce, "operate or tend equipment to control chemical changes or reactions in the processing of ... products. Equipment used includes devulcanizers, steam-jacketed kettles, and reactor vessels."

A few occupations have relatively low employment concentration in Tennessee compared to the national average. These include (1) Architectural and Engineering Managers, (2) Market Research Analysts and Marketing Specialists; (3) Accountants and Auditors, (4) Mechanical Engineers, (5) Chemists, (6) Chemical Plant and System Operators, (7) Petroleum Pump System Operators, Refinery Operators, and Gaugers, (8) Machinists; and (9) Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders.

The average annual number of job openings between 2011 and 2016²⁸ and the number of job postings in the State of Tennessee during 2017 Q2²⁹ is also provided for each occupation. Both statistics can inform higher education and workforce development partners on jobs with high employer demand.

Key postsecondary programs relevant to these job classifications are available in Appendix A.

employment concentration for the given occupation; where location quotient is less than 1.0, Tennessee has a below-average employment concentration for the given job classification.

²⁶ Source for occupation definitions is the U.S. Bureau of Labor Statistics.

²⁷ Assemblers who continuously perform the same task are classified elsewhere in 51-2000.

²⁸ Estimated employment change and turnover for an occupation for a given year. Openings result from job growth and replacement needs resulting from turnover.

²⁹ Source: Jobs4TN, Tennessee Department of Labor and Workforce Development. Advertised jobs are spidered daily in real-time. Real-time advertised jobs are collected from employer corporate sites, hospitals, non-profits, local and federal government agencies, schools and universities, recruiter sites, newspapers, volunteer sites, and other public, private, and state job boards. Each site is individually reviewed and evaluated and each site's data extraction is custom tailored to that site.

Tennessee's Downstream Chemicals Cluster

Expansion of **engineering programs** in the state would improve Tennessee's ability to meet workforce demands of downstream chemicals business. The following programs prepare students for engineering careers in the chemicals sector: Biochemical Engineering; Chemical Engineering; Chemical Engineering, Other; Industrial Engineering; and Mechanical Engineering.

Engineering technology programs prepare Tennessee's workforce for careers as industrial engineers and industrial engineering technicians. There are a variety of these programs, including Packaging Science; Engineering/Industrial Management; Industrial Production Technologies/Technicians, Other; Industrial Technology/Technician; Manufacturing Engineering Technology/Technician; and Engineering Technology, General.

There are only 1176 **chemists** in the state, meaning Tennessee's employment concentration for this position is 34 percent below the national average. Chemists have high wages (median of \$60,000 per year), and employer demand (there were 71 job postings for Chemists in Tennessee in 2017 Q2). The following programs are key to development of Tennessee's chemist workforce: Chemical Physics; Chemistry, General; and Chemistry, Other.

The **physical science technologies/technicians program** serves many chemical-related occupations, including Chemical Technicians, Industrial Engineering Technicians, Chemical Plant and System Operators, and Chemical Equipment Operators and Tenders. There were 263 job postings in 2017 Q2 for these occupations in Tennessee, which all have a median wage above \$20.00 per hour. The latter of these occupations (**Chemical Equipment Operators and Tenders**) is one of the leading occupations for the cluster (comprising 4 percent of the downstream chemicals workforce), has been growing over the last five years, and provides median earnings of \$54,000 per year.

Two **precision production programs** are critical to the development of Tennessee's workforce of **machinists**. There are more than 7300 machinists employed in the state, and employment has risen 17 percent in the last five years. Still, machinist employment concentration in Tennessee is below the national average. Demand for this occupation is high across many industries, with 472 job postings in 2017 Q2 alone, and 998 openings on average each year. Two programs critical to the development of this workforce are the Machine Shop Technology/Assistant program and the Machine Tool Technology/Machinist program.

For each occupation, the table provides a probability of automation.³⁰ This statistic is based on research from Frey and Osborne of Oxford University which analyzes the tasks required of in a job to determine the likelihood that the tasks can be automated in order to estimate the probability that a job will be automated.

³⁰ Frey, Carl Benedickt, and Michael A. Osborne. "The Future of Employment: How Susceptible Are Jobs to Computerisation?" University of Oxford, September 17, 2013. http://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf

Tennessee's Downstream Chemicals Cluster

SOC Code	Occupation	Tennessee (2016)						Probability of Automation	Job Postings in Tennessee (2017 Q2)
		Employment	Employment Change (2011-2016)	Location Quotient	Median Hourly Earnings	Annual Openings	% of Workers Age 55+		
Management									
11-2022	Sales Managers	8,796	16.3%	1.17	\$42.44	939	17.4%	1%	1,769
11-3031	Financial Managers	13,622	15.0%	1.21	\$43.41	1,320	22.3%	7%	81
11-3051	Industrial Production Managers	4,975	16.1%	1.45	\$37.90	466	25.0%	3%	76
11-3071	Transportation, Storage, and Distribution Managers	3,890	23.8%	1.72	\$34.72	405	23.9%	59%	282
11-9041	Architectural and Engineering Managers	3,334	12.1%	0.91	\$55.13	326	29.4%	2%	216
11-1021	General and Operations Managers	43,840	13.1%	0.99	\$40.97	4,178	22.7%	16%	2,049
Business and Financial Operations									
13-1023	Purchasing Agents, Except Wholesale, Retail, and Farm Products	4,034	3.6%	0.66	\$24.73	388	30.7%	77%	126
13-1161	Market Research Analysts and Marketing Specialists	7,212	17.6%	0.63	\$26.10	866	13.2%	61%	597
13-2011	Accountants and Auditors	16,647	7.5%	0.64	\$28.43	1,741	21.9%	94%	2,124
Engineering									
17-2041	Chemical Engineers	704	-0.4%	1.07	\$45.80	64	26.2%	2%	37
17-2112	Industrial Engineers	6,362	18.8%	1.22	\$36.93	622	25.0%	3%	225
17-2141	Mechanical Engineers	4,011	5.5%	0.69	\$41.11	378	22.3%	1%	492
17-3026	Industrial Engineering Technicians	4,233	29.3%	3.24	\$20.93	455	24.0%	3%	55
Life, Physical, and Social Science									
19-2031	Chemists	1,176	-0.3%	0.66	\$28.83	131	26.5%	10%	71
19-4031	Chemical Technicians	1,540	6.0%	1.15	\$21.96	177	26.9%	57%	20
Healthcare Practitioners and Technical									
29-9011	Occupational Health and Safety Specialists	2,130	12.0%	1.33	\$34.05	154	26.1%	17%	69
Sales									
41-4011	Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	8,519	9.9%	1.26	\$31.93	1,102	24.0%	25%	453
41-4012	Sales Representatives, Wholesale and Manufacturing, Except Technical and Scientific Products	21,137	2.4%	0.74	\$25.45	2,530	27.3%	85%	215
Office and Administrative Support									
43-1011	First-Line Supervisors of Office and Administrative Support Workers	33,877	12.1%	1.15	\$23.70	3,720	24.6%	1%	1,038

Tennessee's Downstream Chemicals Cluster

SOC Code	Occupation	Tennessee (2016)						Probability of Automation	Job Postings in Tennessee (2017 Q2)
		Employment	Employment Change (2011-2016)	Location Quotient	Median Hourly Earnings	Annual Openings	% of Workers Age 55+		
43-3031	Bookkeeping, Accounting, and Auditing Clerks	29,942	4.8%	0.94	\$17.34	3,564	32.7%	98%	1,465
43-4051	Customer Service Representatives	58,549	17.3%	1.07	\$14.21	8,570	16.5%	55%	5,104
43-5061	Production, Planning, and Expediting Clerks	7,855	16.9%	1.19	\$22.25	911	23.2%	88%	757
43-5071	Shipping, Receiving, and Traffic Clerks	17,272	12.7%	1.25	\$14.26	2,046	19.9%	98%	374
43-5081	Stock Clerks and Order Fillers	52,923	10.5%	1.30	\$11.24	7,464	19.1%	64%	11
43-6014	Secretaries and Administrative Assistants, Except Legal, Medical, and Executive	54,626	9.9%	1.17	\$14.62	6,402	31.9%	96%	124
43-9061	Office Clerks, General	52,645	7.0%	0.88	\$14.26	6,586	26.8%	96%	340
Installation, Maintenance and Repair									
49-1011	First-Line Supervisors of Mechanics, Installers, and Repairers	10,431	11.6%	1.14	\$28.49	1,075	28.0%	0%	436
49-9041	Industrial Machinery Mechanics	8,471	20.7%	1.24	\$22.34	975	27.0%	67%	137
49-9043	Maintenance Workers, Machinery	4,183	23.6%	2.24	\$21.87	535	26.8%	86%	312
49-9071	Maintenance and Repair Workers, General	29,393	12.7%	1.08	\$17.53	3,187	28.5%	64%	825
Production									
51-1011	First-Line Supervisors of Production and Operating Workers	16,026	11.6%	1.30	\$25.22	1,858	23.6%	2%	1,389
51-2092	Team Assemblers	61,934	32.0%	2.75	\$14.51	9,660	19.0%	97%	161
51-4021	Extruding and Drawing Machine Setters, Operators, and Tenders, Metal and Plastic	1,979	6.5%	1.36	\$15.85	273	17.9%	91%	20
51-4041	Machinists	7,376	16.9%	0.95	\$19.09	998	26.5%	65%	472
51-6091	Extruding and Forming Machine Setters, Operators, and Tenders, Synthetic and Glass Fibers	668	-0.1%	1.67	\$20.09	114	22.7%	88%	8
51-8091	Chemical Plant and System Operators	593	-13.8%	0.89	\$23.08	88	28.1%	85%	39
51-8093	Petroleum Pump System Operators, Refinery Operators, and Gaugers	210	-2.8%	0.25	\$23.45	35	27.6%	71%	3
51-9011	Chemical Equipment Operators and Tenders	2,739	1.2%	1.82	\$25.93	362	22.1%	76%	149
51-9012	Separating, Filtering, Clarifying, Precipitating, and Still Machine Setters, Operators, and Tenders	727	3.7%	0.75	\$14.27	100	18.4%	88%	18
51-9023	Mixing and Blending Machine Setters, Operators, and Tenders	3,058	2.0%	1.15	\$17.82	442	20.6%	83%	32
51-9041	Extruding, Forming, Pressing, and Compacting Machine Setters, Operators, and Tenders	2,599	8.5%	1.79	\$14.07	366	18.8%	93%	54
51-9061	Inspectors, Testers, Sorters, Samplers, and Weighers	13,634	15.8%	1.30	\$15.77	1,932	25.5%	98%	436

Tennessee's Downstream Chemicals Cluster

SOC Code	Occupation	Tennessee (2016)						Probability of Automation	Job Postings in Tennessee (2017 Q2)
		Employment	Employment Change (2011-2016)	Location Quotient	Median Hourly Earnings	Annual Openings	% of Workers Age 55+		
51-9111	Packaging and Filling Machine Operators and Tenders	9,518	14.3%	1.21	\$14.54	1,336	18.4%	98%	84
51-9121	Coating, Painting, and Spraying Machine Setters, Operators, and Tenders	2,349	12.9%	1.35	\$15.77	319	16.0%	91%	48
51-9198	Helpers--Production Workers	20,926	18.9%	2.42	\$11.49	3,606	16.1%	66%	526
51-9199	Production Workers, All Other	7,084	19.1%	1.35	\$13.86	1,045	16.8%	92%	1,629
53-3032	Heavy and Tractor-Trailer Truck Drivers	57,339	12.4%	1.65	\$18.96	7,473	28.3%	79%	6,869
53-7051	Industrial Truck and Tractor Operators	17,476	28.6%	1.58	\$14.28	2,454	15.8%	93%	1,052
53-7062	Laborers and Freight, Stock, and Material Movers, Hand	94,456	20.1%	1.81	\$12.41	14,971	15.6%	85%	2,263
53-7064	Packers and Packers, Hand	18,276	19.4%	1.26	\$10.22	3,104	17.3%	38%	370

Sources: EMSI 2017 Q.2 and Jobs4TN

ADVANTAGES AND OPPORTUNITIES FACING TENNESSEE'S DOWNSTREAM CHEMICALS CLUSTER

* Trends marked with an asterisk were identified through review of seven IBISWorld Industry reports.³¹

Construction growth.* The construction sector is a key downstream market for many chemical products, and is projected to grow over the next five years. The construction sector purchases interior and exterior paints, as well as coatings, to support new construction and renovations of residential and commercial buildings. The dyes and pigment industry provides key inputs to paint, and therefore also grows with the construction sector. The construction sector accounts for one third of the adhesive industry's revenues, where adhesives are used for a number of construction-related activities including tiling, dry-walling, and caulking. Explosives, which are used in the demolition of buildings, also experience simultaneous growth.

Manufacturing growth.* The manufacturing sector is projected to grow over the next five years, creating greater demand for many downstream chemicals industries. Manufacturing expansion will require paints (applied to motor vehicles and other consumer goods), as well as dyes and pigments which are utilized in paints, inks and other goods. The adhesives industry supplies consumer packaging production, as well as automotive manufacturers with products "to bond mirrors to vehicles, as well as to bond interior fabric to the plastic bolster.

³¹ Trends marked with an asterisk were identified through analysis of the following seven reports by IBISWorld: "Dye and Pigment Manufacturing in the US." (June 2017); "Paint Manufacturing in the US." (November 2016); "Adhesives Manufacturing in the US." (May 2017); "Soap & Cleaning Compound Manufacturing in the US." (September 2016); "Cosmetic & Beauty Products Manufacturing in the US." (May 2017); "Explosives Manufacturing in the US." (October 2016); "Chemical Product Manufacturing in the US." (June 2017).

Tennessee's Downstream Chemicals Cluster

Furthermore, adhesives are used to bond gaskets to engine parts and chassis.³² Adhesives are also a lighter substitute to mechanical fasteners—which is appealing to motor vehicle producers that face rising demand for more light-weight, fuel-efficient vehicles. The industrial production index, an indicator of manufacturing and other industrial production activity, will also coincide with a rise in industrial construction and demand for explosives.

Foreign Markets.* Many industries of the downstream chemicals cluster are looking at growth opportunities in foreign markets. Growing construction markets in emerging economies presents opportunities for producers of synthetic dyes and pigments (key component of interior and exterior paints), as well as explosives (used in construction for the demolition of structures). Synthetic dye and pigment producers have identified opportunity in supplying growing manufacturing establishments abroad, including China's automotive industry. The adhesives industry may experience heightened demand from the growing Chinese and Indian aviation industry, which has been sparked by rising incomes and increased passenger travel. Currently, exports to Canada and Mexico account for approximately half of the adhesive industry's exports. Manufacturers of other chemical products have experienced greater demand for their exports, which account for nearly 17 percent of the industry's revenue. High population and income growth in emerging markets, as well as few competitors, provide a strong customer base for the soap and cleaning compounds industry.

CHALLENGES FACING TENNESSEE'S DOWNSTREAM CHEMICALS CLUSTER

* Trends marked with an asterisk were identified through review of seven IBISWorld Industry reports.³³

Strengthening US dollar.* Demand for downstream chemicals products produced in Tennessee and elsewhere in the United States has been negatively influenced in recent years by appreciation of the US dollar. As appreciation occurs, products made in the United States become more expensive relative to those manufactured elsewhere, thereby reducing demand for US-made products abroad. In addition to straining export growth, imports of lower-cost chemical products heighten competition within the domestic market. Foreign-based producers of soaps, cosmetics and paints, for example, have inundated the U.S. market with low-cost alternatives to products made in the U.S. Companies based in the United States are responding in a number of ways to maintain competitiveness—such as investing in research & development to identify new products and niches; consolidating operations to improve efficiencies; and looking to new emerging markets.

Volatility in price of crude oil.* The price of crude oil has experienced recent volatility, and is projected to rise in the next five years to 2022. Petrochemical feedstock (a byproduct of oil) is a primary input commodity for most downstream chemical products—including soaps, cleaning

³² "Adhesive Manufacturing in the US" (May 2017). IBISWorld.

³³ Trends marked with an asterisk were identified through analysis of the following seven reports by IBISWorld: "Dye and Pigment Manufacturing in the US." (June 2017); "Paint Manufacturing in the US." (November 2016); "Adhesives Manufacturing in the US." (May 2017); "Soap & Cleaning Compound Manufacturing in the US." (September 2016); "Cosmetic & Beauty Products Manufacturing in the US." (May 2017); "Explosives Manufacturing in the US." (October 2016); "Chemical Product Manufacturing in the US." (June 2017).

Tennessee's Downstream Chemicals Cluster

products, cosmetics and other toiletries, paints and coatings, and adhesives. Chemical producers can increase the price of their products to account for rising input prices, however commonly do not respond to these volatile fluctuations in order to maintain competitiveness.

Growing Emphasis on R&D.* Downstream chemical manufacturers will continue to increase investment in research & development in order to develop new product lines and increase their competitiveness in the global marketplace. The adhesives industry is committed to “making significant advances in research and development to ensure that it uses technologically advanced equipment that can produce adhesives more affordably and efficiently. Moreover, today’s adhesive formulas are becoming increasingly ‘greener,’ helping auto producers to meet new emissions and efficiency requirements.”³⁴ Manufacturers of soap and cleaning products are also investing resources into high-quality eco-friendly products and products that reduce the amount of time required to clean. In the cosmetic and beauty products line of business, identification of “advanced ingredients” and “premiumization” have been a focus of research and development efforts. Companies with strong commitments to research and development will increase spending on labor to hire and retain a skilled workforce that can support such activity.

Workforce gaps. Tennessee’s state and local higher education and workforce development stakeholders should ensure adequate training programs are in place to prepare Tennessee’s workforce for careers in downstream chemicals. This includes postsecondary programs in engineering, chemistry and precision production, among others. This also includes curriculum development in middle school and high school; and industry-specific training programs for non-students.

Baby boomer retirements. A quarter of the downstream chemicals workforce will be reaching retirement age in the next 10 years or is already of retirement age (nearly 2,300 workers are age 55 or older). Retirements of the baby boomer cohort will cause significant disruption across businesses in the United States. Many occupations that are key to the downstream chemicals industry have a high share of workers approaching retirement age in the next 10 years, include Architectural and Engineering Managers (29.4 percent), Chemical Plant and System Operators (28.1 percent), Industrial Machinery Mechanics (27.0 percent), Chemical Technicians (26.9 percent), Chemists (26.5 percent), Machinists (26.5 percent), Chemical Engineers (26.2 percent) and Industrial Engineers (25.0 percent). Companies will respond to this shift in a number of ways, including greater adoption of automation, geographic relocations, consolidation and acquisition. Tennessee’s cluster of downstream chemicals companies can inform higher education partners of curriculum needs.

Automation. Technological advances will likely continue to change the job requirements of modern jobs. Tasks with a high probability of automation have the potential to be transferred from human labor to technology-supplied labor. As technology changes the assemblage ratios of human-assigned tasks to technology-assigned tasks, so too will there be an emergence of new human-assigned tasks that support and work in tandem with the technological advances. Providing the workforce with the knowledge, skills, and abilities to navigate the coming changes in the tasks of future jobs is a key step in avoiding disruption to the labor market supply pipeline. In a recent Brookings Institution study³⁵ of the geographic distribution of the use of industrial robots (“automatically controlled, reprogrammable machines” capable of

³⁴ IBISWorld report “Adhesive Manufacturing in the US” (May 2017).

³⁵ Brookings Institution report “Where the robots are” (August 14, 2017). <https://www.brookings.edu/blog/the-avenue/2017/08/14/where-the-robots-are/>

Tennessee's Downstream Chemicals Cluster

replacing labor in a range of tasks), Tennessee was found to have the sixth highest concentration of robots per thousand workers in the United States in 2015.

Regulations.* The creation of new government regulation can generate challenges for chemical companies. Paint producers have had to invest resources to respond to new regulations on the chemical composition of their products. The soap and cleaning industry is also facing pending regulations. Downstream chemical companies will experience rising costs associated with disruptions to business processes and output that new regulations create.

RECOMMENDATIONS

Increase communication. Establish channels through which communication between downstream chemical companies and key stakeholders occurs, with support from business development representatives and industry-specific organizations. Increased engagement across cluster participants can generate knowledge of common concerns and trends; and lead to the identification of new solutions, partnerships or other benefits.

Supply chain development. Offer business development consultation to companies within the supply chain of the downstream chemicals sector. Identify components of the supply chain where there is opportunity for greater partnerships with Tennessee companies. Identify Tennessee companies within the downstream cluster supply chain, and connect them with in-state downstream chemicals companies.

Target recruitment of companies located outside the state which support the supply chain of Tennessee's downstream chemicals cluster.

Workforce development: Ensure there are sufficient programs offered at higher education institutions to support the types of job openings downstream chemical companies' need to fill now and in the future. The workforce development community should target relevant occupations with low employment concentration, high numbers of job postings, or a high share of workers reaching retirement age.

Tennessee should also ensure there are appropriate educational pathways available in middle school and high school to prepare students for pursuing degrees suited for the chemicals field.

Businesses can encourage interest in chemicals-related fields by offering internships and apprenticeships to college students. Creating partnerships with middle schools and high schools to increase communication with students and teachers may also increase interest and encourage students to pursue chemical careers.

Marketing. Develop material to market the state's downstream chemicals cluster. Marketing material can support the retention and recruitment of downstream chemicals company to the state, as well as suppliers and customers of the downstream chemicals cluster.

APPENDIX A: HIGHER EDUCATION—KEY PROGRAMS

The following programs provide educational pathways for careers in the downstream chemicals cluster.³⁶ To see the top 50 occupations these programs support, see the “Staffing Patterns” section. Note: some occupations have multiple supporting higher education programs; other occupations do not require any postsecondary education.

- **Chemistry, General (CIP 40.0501)** This program provides pathways for employment as Chemists.
Thirty-three Tennessee institutions have had students complete this program, including UT-Knoxville, Vanderbilt, ETSU, TTU, University of Memphis, MTSU, UT-Chattanooga, TSU, Austin Peay, Rhodes, UT-Martin, Sewanee, Belmont, Union University, and Southern Adventist University. In 2016, a total of 447 students completed a Chemistry, General program in Tennessee—with 74 percent of these completers receiving a Bachelor’s degree, 16 percent receiving a Master’s degree, and 9 percent receiving a doctorate. In the last five years (2011 to 2017), 2,531 students completed this program, and in the last ten years (2007 to 2016), 4,030 students completed this program.
- **Chemistry, Other (CIP 40.0599)** This program provides pathways for employment as Chemists.
Five Tennessee institutions have had students complete this program, including Carson-Newman University, Lane College, Belmont, King University, and Sewanee. There have been 50 completions in the last five years, and 70 completions in the last ten years.
- **Chemical Physics (CIP 40.0508)** This program provides pathways for employment as Chemists.
Maryville College offers this program, but there have been very few completers of the program—3 completers in the last ten years.
- **Physical Science Technologies/Technician (CIP 41.03)** This program contains two sub-programs: 1) Chemical Technology/Technician and 2) Chemical Process Technology. These programs provide pathways for employment as Chemical Technicians, Industrial Engineering Technicians, Chemical Plant and System Operators, and Chemical Equipment Operators and Tenders.
Chattanooga State Community College and Cleveland State Community College have a Chemical Process Technology program, with 21 and 5 students completing the program in 2016, respectively. This program has had 496 completers in the last five years.
Northeast State Community College, UT-Knoxville, Chattanooga State Community College, Southwest Tennessee Community College, and Pellissippi State Community College have a Chemical Technology/Technician program, but only Northeast State Community College and UT-Knoxville have had recent completers of the program. This program has had 48 completers in the last five years, and 71 completers in the last 10 years.
- **Chemical Engineering (CIP Code 14.0701)** This program provides pathways for employment as Chemical Engineers.
Five Tennessee institutions offer this program, including UT-Knoxville, Tennessee Technological University, Vanderbilt University, UT-Chattanooga, and Christian Brothers University. There were 225 completions in 2016, 88 percent of which were Bachelor’s degrees, 5

³⁶ Source: Analysis of EMSI. EMSI sources program and completion data from the Integrated Postsecondary Education Data System (IPEDS), the data collection program for the US Department of Education’s National Center for Education Statistics (NCES).

Tennessee's Downstream Chemicals Cluster

percent were Master's degrees, and 7 percent were doctorates. In the last five years, 1,072 students completed this program. In the last ten years, 1,427 students completed this program.

- **Chemical Engineering, Other (CIP Code 14.0799)** This program provides pathways for employment as Chemical Engineers. UT-Knoxville offers this program, and there have been 13 completers in the last ten years.
- **Biochemical Engineering (CIP Code 14.4301)** This program provides pathways for employment as Chemical Engineers. Christian Brothers University offers this program, and there have been 6 completers in the last ten years.
- **Mechanical Engineering (CIP Code 14.1901)** This program provides pathways for employment as Mechanical Engineers. Nine Tennessee institutions offer this program, including Tennessee Tech, UT-Knoxville, Vanderbilt, UT-Chattanooga, University of Memphis, Lipscomb, TSU, Christian Brothers University, and Union University. There were 512 completions in 2016, of which 90 percent were Bachelor's degrees. In the last five years, there have been 2,672 completions from Tennessee institutions, and 3,953 in the last ten years.
- **Industrial Engineering (CIP Code 14.3501)** This program provides pathways for employment as Industrial Engineers. Three Tennessee institutions offer this program, including UT-Knoxville, University of Memphis, and Tennessee Tech. In recent years, the completions of this program have almost exclusively come from UT-Knoxville. In the last ten years, there have been 552 completions of this program from Tennessee institutions.
- **Engineering Technology, General (CIP Code 15.0000)** This program provides pathways for employment as Industrial Engineering Technicians. Nine Tennessee institutions offer this program, including Chattanooga State Community College, Pellissippi State Community College, Nashville State Community College, Motlow State Community College, ETSU, Tennessee Tech, MTSU, Austin Peay, and University of Memphis. In 2016, there were 547 completions, of which 20 percent were a certificate of less than 1 year, 36 percent were Associates degrees, and 40 percent were Bachelor's degrees. There have been 3,550 completions in the last 10 years.
- **Industrial Technology/Technician (CIP Code 15.0612)** This program provides pathways for employment as Industrial Engineering Technicians. Twelve Tennessee institutions offer this program—9 community colleges and 3 four-year schools. In 2016, there were 173 completions, of which 21 percent were a certificate of less than 1 year, 72 percent were Associate's degrees, and 8 percent were Master's degrees. There have been 1,489 completions in the last ten years.
- **Manufacturing Engineering Technology/Technician (CIP Code 15.0613)** This program provides pathways for employment as Industrial Engineering Technicians and Industrial Engineers.

Tennessee's Downstream Chemicals Cluster

This program is offered at Nashville State Community College, Pellissippi State Community College, Jackson State Community College, Southwest Tennessee Community College, TCAT-Pulaski, TCAT-Jackson, and University of Memphis. In 2016, 58 students completed this program. In the last five years, 177 students have completed this program. In the last ten years, 242 students have completed this program.

- **Industrial Production Technologies/Technicians, Other (CIP Code 15.0699)** This program provides pathways for employment as Industrial Engineering Technicians.

Austin Peay State University offers this program. There have been 137 completions in the last five years.

- **Engineering/Industrial Management (CIP Code 15.1501)** This program provides pathways for employment as Industrial Engineering Technicians.

This program is offered at UT-Chattanooga, MTSU, Christian Brothers University, Lipscomb University, UT-Knoxville, and Vanderbilt. There were 132 completions in 2016, of which 47 percent were Bachelor's degrees and 47 percent were Master's degrees. In the last ten years, there have been 1,166 completions from this program in Tennessee.

- **Packaging Science (CIP Code 15.1503)** This program provides pathways for employment as Industrial Engineering Technicians and Industrial Engineers.

Christian Brothers University offers this program, and there have been 6 completers in the last five years.

- **Industrial Mechanics and Maintenance Technology (CIP Code 47.0303)** This program provides pathways for employment as Industrial Machinery Mechanics and Machinery Maintenance Workers.

This program is offered at 22 TCATS and 5 community colleges in Tennessee. There were 490 completions in 2016, of which 76 percent were certificates of at least 1 one but less than 2 academic years. This program is offered at 3 certificate levels, as well as at the Associates degree level. There have been 2,676 completions in the last five years, and 3,999 completions in the last ten years.

- **Heavy/Industrial Equipment Maintenance Technologies, Other (CIP Code 47.0399)** This program provides pathways for employment as Industrial Machinery Mechanics and Machinery Maintenance Workers.

Six TCATs as well as William Moore College of Technology offers this program. There were no completions in 2016. In the last five years, there were 132 completions. In the last ten years, there were 314 completions.

- **Machine Tool Technology/Machinist (CIP Code 48.0501)** This program provides pathways for employment as Machinists and as Extruding and Drawing Machine Setters, Operators, and Tenders (Metal and Plastic).

This program is offered at 17 TCATs as well as William Moore College of Technology and Nashville State Community College. There were 224 completions of this program in 2016. There have been 829 completions in the last five years, and 1,160 completions in the last ten years.

Tennessee's Downstream Chemicals Cluster

- **Machine Shop Technology/Assistant (CIP Code 48.0503)** This program provides pathways for employment as Machinists.
This program is offered at 22 TCATS as well as Northeast State Community College and Motlow State Community College. There were 143 completions in 2016. There have been 1,228 completions in the last five years, and 2,103 completions in the last ten years.
- **Food Science (CIP Code 1.1001)** This program provides pathways for employment as Chemical Technicians.
UT-Knoxville offers this program, and there were 71 completions in 2016—of which 79 percent were Bachelor's degrees. There have been 397 completions from this program in the last ten years.
- **Radiation Protection/Health Physics Technician (CIP Code 21.0916)** This program provides pathways for employment as Occupational Health and Safety Specialists.
Fountainhead College of Technology offers this program. There have been 75 completions in the last five years.
- **Health Services/Allied Health/Health Sciences, General (CIP Code 51.0000)** This program provides pathways for employment as Occupational Health and Safety Specialists.
Sixteen Tennessee institutions have offered this program. There were 715 completions in 2016, of which 90 percent were certificates of less than 1 academic year, 4 percent were Bachelor's degrees, and 6 percent were Master's degrees. There have been 2,931 completions in the last five years.
- **Environmental Health (CIP Code 51.2202)** This program provides pathways for employment as Occupational Health and Safety Specialists.
This program is offered at Roane State Community College and East Tennessee State University. Nine associate's degrees and 8 Bachelor's degrees were awarded from this program in 2016 (a total of 17 completions). In the last five years, there were 124 completions. In the last ten years, there were 170 completions.
- **Building/Property Maintenance (CIP Code 46.0401)** This program provides pathways for employment as Maintenance and Repair Workers.
This program is offered at TCAT-Paris, William Moore College of Technology, and Southern Adventist University. Twenty certificates and one Associate's degree were awarded in 2016 (a total of 21 completions). In the last five years, there were 116 completions.
- **Truck and Bus Driver/Commercial Vehicle Operator and Instructor (CIP Code 49.0205)** This program provides pathways for employment as Heavy and Tractor-Trailer Truck Drivers.
Seventeen Tennessee institutions offer this program. There were 532 certificates awarded in 2016, of which 298 were awarded at a Miller-Motte Technical College campus (Clarksville, Madison, and Chattanooga). There have been 2,926 completions in the last 10 years from this program in Tennessee.

Tennessee's Downstream Chemicals Cluster

- **Accounting and Related Services (52.03)** This program includes five sub-programs 1) Accounting 2) Accounting Technology/Technician and Bookkeeping 3) Accounting and Finance 4) Accounting and Business/Management 5) Accounting and Related Services, Other. These programs provide pathways for employment as Accountants and Auditors and as Bookkeeping, Accounting, and Auditing Clerks.

Fifty-five Tennessee institutions offer these programs, and there were 1,422 completions in 2016—of which 68 percent were Bachelor's degrees and 26 percent were Master's degrees. There have been 8,628 completions in the last five years, and 13,348 completions in the last ten years.