



**UUP**  
The Ohio Urban University Program

Prepared for:  
**NORTECH**

Prepared by:  
**Iryna Lendel, Ph.D.**  
**Ziona Austrian, Ph.D.**

February 2009

**Center for  
Economic  
Development**



# **NORTHEAST OHIO HIGH-TECH ECONOMY REPORT**

Prepared for:

**NORTECH**

Prepared by:

Iryna Lendel, Ph.D.

Ziona Austrian, Ph.D.

February 2009

2121 Euclid Avenue Cleveland, Ohio 44115  
<http://urban.csuohio.edu/economicdevelopment>

# TABLE OF CONTENTS

EXECUTIVE SUMMARY .....	i
SUMMARY OF HIGH TECH SECTOR PERFORMANCE .....	ii
SUMMARY OF BIOSCIENCE SECTOR PERFORMANCE .....	iv
INTRODUCTION .....	1
METHODOLOGY.....	3
ANALYSIS OF HIGH TECH INDUSTRIES.....	3
RESEARCH & DEVELOPMENT ANALYSIS .....	4
BIO SCIENCE SECTOR ANALYSIS.....	5
HIGH-TECH INDUSTRIES: OVERALL TRENDS AND GEOGRAPHIC DISTRIBUTION.....	6
EMPLOYMENT TRENDS .....	6
EMPLOYMENT IN NEO'S SUB-REGIONS .....	9
AVERAGE WAGE TRENDS.....	10
HIGH-TECH INDUSTRIES BY TECHNOLOGY GROUP .....	13
EMPLOYMENT BY TECHNOLOGY GROUP.....	13
AVERAGE WAGES, GROSS REGIONAL PRODUCT AND PRODUCTIVITY BY TECHNOLOGY GROUP .....	16
THE BIOSCIENCE SECTOR IN NORTHEAST OHIO .....	19
BIOSCIENCE EMPLOYMENT TRENDS .....	19
BIOSCIENCE PAYROLL TRENDS .....	22
BIOSCIENCE AVERAGE WAGE TRENDS .....	23
TRENDS IN BIOSCIENCE ESTABLISHMENTS .....	24
RESEARCH & DEVELOPMENT.....	25
INDUSTRY RESEARCH & DEVELOPMENT.....	25
ACADEMIC RESEARCH & DEVELOPMENT .....	26
INSTITUTIONAL RESEARCH.....	29
CONCLUDING REMARKS AND POLICY IMPLICATIONS .....	30
APPENDIX A: NORTECH SERVICE AREA .....	32
APPENDIX B: DETAILED TABLES AND FIGURES FOR THE HIGH-TECH SECTOR.....	33
APPENDIX C: BIOSCIENCE SECTOR INDUSTRY DESCRIPTION AND DETAILED ANALYSIS.....	41

## LIST OF TABLES

Table I.	NEO High-Tech Industry Groups, 2004-2007.....	ii
Table II.	NEO Bioscience Sector, 2007 .....	iv
Table 1.	Total and High-Tech Employment in NEO and U.S., 2000-2007.....	6
Table 2.	Total and High-Tech Employment in NEO and U.S., Percentage Change.....	7
Table 3.	High-Tech Employment Share: NEO Metropolitan Areas, 2006-2007 .....	10
Table 4.	NEO Employment by Technology Group, 2007.....	13
Table 5.	Employment Share by Technology Group: NEO, the Midwest and U.S., 2004-2007 .....	13
Table 6.	Average Wage by Technology Group: NEO, the Midwest and U.S., 2004-2007 .....	16
Table 7.	GRP by Technology Group: NEO, the Midwest and U.S., 2004-2007 .....	17
Table 8.	Productivity by Technology Groups, NEO, the Midwest and U.S., 2004-2007 .....	18
Table 9.	Bioscience Shares of Total Employment and Payroll .....	20
Table 10.	Average Wage in Bioscience, 2007.....	23
Table 11.	Estimated Industry R&D Funding by Sub-Region, 2000-2006 .....	25
Table 12.	Estimated Industry R&D Funding per Employee, 2000-2006 .....	26
Table 13.	R&D Expenditures at NEO Colleges and Universities by Funding Source, FY 2006.....	27
Table 14.	R&D Expenditures at Northeast Ohio Colleges and Universities, FY 2000-2006 .....	28
Table 15.	Academic R&D Expenditures per Employee, 2000-2006 .....	28
Table B-1.	Employment Change by Technology Group: NEO, the Midwest and U.S. 2004-2007, Percentage Change.....	36
Table B-2.	GRP Change by Technology Group: NEO, the Midwest and U.S., 2004-2007 .....	37
Table B-3.	Share of Total GRP by Technology Group, NEO, the Midwest and U.S., 2004-2007 .....	38
Table B-4.	Change of R&D Expenditures at NEO Colleges and Universities by Funding Source, 2005-2006.....	39
Table C-1.	Bioscience Sector Industries .....	41
Table C-2.	Employment Change in Bioscience Segments: NEO, Ohio, and the U.S., 2000-2007 .....	42

## LIST OF FIGURES

Figure 1.	Total Employment and High-Tech Employment Since 2004 .....	6
Figure 2.	High-Tech Employment Share: NEO, Midwest and U.S., 2004 to 2007 .....	8
Figure 3.	Total High-Tech Employment by MSA, 2007.....	9
Figure 4.	Average Wages in High-Tech, Non-High-Tech and All Industries: NEO, the Midwest and U.S., 2006 and 2007 .....	11
Figure 5.	Employment Change in Bioscience: NEO, Ohio, and the U.S., 2000-2007 .....	20
Figure 6.	Total NEO Bioscience Employment by Segment, 2007.....	21
Figure 7.	Payroll Change in Bioscience Segments: NEO, Ohio, and the U.S., 2000-2007 .....	22
Figure 8.	Average Wage Change in Bioscience Segments: NEO, Ohio, and the U.S., 2000-2007 .....	24
Figure B-1.	Employment Change: NEO, the Midwest, and U.S., 2006-2007 .....	34
Figure B-2.	Total High-Tech Employment by MSA: Percentage Change, 2004-2006, 2006-2007 .....	34
Figure B-3.	NEO High-Tech Employment Change by Technology Group: 2004-2006, 2006-2007 .....	35
Figure B-4.	Employment Change by Technology Group: NEO, the Midwest, and U.S., 2004-2007 .....	35
Figure B-5.	Productivity Change by Technology Group, NEO, the Midwest and U.S., 2006-2007 .....	38
Figure B-6.	Change in Estimated Industry R&D Funding .....	39
Figure B-7.	Change in Academic R&D Expenditures, 2000-2006 .....	40



## EXECUTIVE SUMMARY

This study is an update of two previous reports commissioned by the Northeast Ohio technology Coalition (NorTech) that examined the high-tech sector in Northeast Ohio (NEO). It focuses on two time periods: 2004-2007, the last recovery period, and 2006-2007, the latest one-year change. Four major perspectives are reflected in this year's analysis: (1) changes in overall NEO high-tech trends in comparison to the Midwest and the United States, (2) analysis of technology groups within the high-tech sector, (3) detailed analysis of bioscience in Northeast Ohio using the industry definition adopted by BioOhio, and (4) track of the NEO research and development activity in industry and academia. The study includes an analysis of four indicators of high-technology: employment, average wages, gross regional product, and productivity.

This study includes two analyses based on Daniel Hecker's industry definition of high-tech:<sup>1</sup> the changes in the high-tech sector as a whole and analysis of the 46 high-tech industries based on groupings by eight high-tech groups. The typology of eight groups includes: Advanced Manufacturing; Advanced Materials; Pharmaceuticals; Electronics; Energy and Power & Propulsion; Information and Communication Technology; Management, Sales, and Facility Support Services (primarily comprised of headquarters of companies); and Science and Engineering.

Northeast Ohio has a strong bioscience sector. Because many of the industries included in the bioscience sector are not included in Hecker's definition of high-tech industries, this study describes the NEO bioscience sector in detail using the definition adopted by BioOhio.<sup>2</sup> The study examines research and development activity in the region by looking at industry R&D funding and R&D expenditures of academic institutions.

---

<sup>1</sup> Daniel Hecker, an economist at the U.S. Bureau of Labor Statistics (BLS), identifies 46 four-digit NAICS industries as high-tech according to a portion of that industry's employment in technology-oriented occupations. Daniel E. Hecker "High-technology employment: a NAICS-based update." *Monthly Labor Review*, pp. 57-72, July 2005.

<sup>2</sup> *Ohio Bioscience Growth Report*, December 2007.

Summarizing major findings, the highlights of the dynamic of NEO high-tech industry is the following:

**Table I. NEO High-Tech Industry Groups, 2004-2007**

Technology Group	Percentage Change: 2004-2007				Percentage Change: 2006-2007			
	Employment	GRP	Productivity	Wages	Employment	GRP	Productivity	Wages
Advanced Manufacturing	5.6	15.4	9.5	2.9	0.9	4.1	3.3	-3.2
Advanced Materials	-5.1	7.4	11.6	17.9	-2.0	2.0	5.2	11.0
Electronics	-0.3	17.6	21.0	9.9	0.5	3.1	-0.4	3.1
Energy and Power & Propulsion	4.1	23.3	30.7	15.3	3.8	6.8	8.4	-0.7
Information & Communication	N/A	9.3	N/A	N/A	5.8	5.9	1.6	-0.8
Mgmt, Sales & Facilities Support	-2.6	1.5	-4.4	23.2	-0.9	-1.7	-2.5	3.3
Pharmaceuticals	N/A	25.8	N/A	N/A	2.7	-3.8	-11.8	-1.2
Science & Engineering	13.6	19.3	6.7	4.0	3.5	2.3	3.4	0.1
Total High-Tech	2.7	11.6	6.8	12.2	1.4	2.6	1.7	1.9
Total, All Industries	-0.2	4.9	4.6	5.7	-0.8	1.2	1.2	3.0

## SUMMARY OF HIGH TECH SECTOR PERFORMANCE

- ✓ Between 2006 and 2007 (the latest year for which data is available), NEO high-tech employment grew by 1.4% (2,395 jobs) (Table I). By contrast, total NEO employment reversed its 2004 to 2006 growth trend and declined between 2006 and 2007. The decline was 0.8%, reflecting the loss of almost 16,000 jobs. Both measures of employment lagged the national trends; the U.S. high-tech sector grew by 2.6% and the U.S. economy added 1.4% to employment for all jobs from 2006 to 2007.
- ✓ NEO high-tech employment has been growing consistently since its lowest level in 2003 and the percentage growth during the last 3 years (2004-2007) is accelerating. From 2006 to 2007, NEO high-tech employment was growing at a slightly higher rate than the average of all Midwest states (1.42% compared to 1.29%). This is remarkable considering that the total employment in the Midwest was virtually unchanged (0.002%). However, even at the existing annual growth rate of 1.4% from 2006 to 2007, the growth rate in Northeast Ohio falls far short of the growth rate in the United States, which was 2.6% for the same period.
- ✓ Since 2004, NEO's share of high-tech employment in the total employment is consistently growing, reaching 8.53% in 2007 (0.23% increase since 2004). This growth is due to a slight increase in high-tech employment and a decline in total employment in Northeast Ohio. Although NEO's share of high-tech employment is lagging both the Midwest and the United States in all years, some sub regions within Northeast Ohio have higher shares. The Cleveland MSA's share of high-tech employees (9.9%) and the Akron MSA's share (10.9%) are higher than the shares in the Midwest (9.02%) and the United States (9.53%).
- ✓ In 2007, the average wage in high-tech industries in Northeast Ohio was \$70,985 compared to \$69,603 in 2006. From 2006 to 2007, the average wages of NEO high-tech industries were growing almost at the same rate as the Midwest. The

gap between high-tech average wages in Northeast Ohio and the United States narrowed from 24.1% in 2006 to 22.8% in 2007. However, the gap in average wages between Northeast Ohio and the United States was much larger in high-tech industries than in all industries. In 2007, Northeast Ohio lagged the United States in all industries' average wages by 13.8%, while the high-tech industries' wages were lagging the United States by 22.8%.

- ✓ The geographical distribution of high-tech employment illustrates that, in 2007, four larger metropolitan areas—Cleveland-Elyria-Mentor, Akron, Youngstown, and Canton-Massillon—together accounted for 85% of all NEO high-tech employment. The Cleveland-Elyria-Mentor MSA captured the largest share of NEO high-tech employment, holding at 59.7% for the past 2 years. Akron retained the highest concentration of high-tech jobs, where almost 11% of its total employment was in high-tech industries.
- ✓ Analyzing the high-tech sector in Northeast Ohio by eight technology groups reveals that in 2007 the largest groups were Management, Sales, and Facilities Support (primarily comprised of headquarters and accounting for 30% of all jobs in high-tech industries), Science & Engineering (16%), and Information and Communication (16%). The next three largest groups—Advanced Manufacturing, Electronics, and Advanced Materials—combined accounted for 29% of high-tech employment.
- ✓ From 2006 to 2007, the largest group, Management, Sales, and Facilities Support lost 443 employees (-0.9%) while Advanced Materials lost 323 jobs (-2%); both groups have been continuously losing employment since 2004. All other technology groups gained employment, led by two groups that accounted for 77% of the total job growth in high-tech industries: the Information and Communication sector gained 1,469 employees (5.8% growth from 2006) and Science and Engineering added 956 jobs (3.5% gain from 2006). Another important technology group, Energy and Power & Propulsion, added 460 jobs (3.8% growth).
- ✓ Only the Advanced Materials group paid average wages in Northeast Ohio higher than that in the Midwest and the United States (\$77,481, compared to \$73,155 and \$76,001, respectively). Average wages in this sector increased 11% in Northeast Ohio over the last year, the highest growth of all groups in Northeast Ohio and the highest growth among all technology groups in the Midwest and the United States.
- ✓ Two more technology groups were trying to catch up in average wages with the Midwest and the United States over the last 3 years. Energy and Power & Propulsion grew faster than the Midwest and the United States between 2004 and 2007 (15.3% compared to 12.3% and 9.0%, respectively). Electronics increased their average wages 10% over the last 3 years, growing almost 3 times faster than the United States and 5 times faster than the Midwest. Between 2006 and 2007, the Electronics group increased their wages by 3.1%, while both the Midwest and the United States declined (-1.9% and -4.8%, respectively).
- ✓ Between 2004 and 2007, the gross regional product (GRP) generated by high-tech industries in Northeast Ohio increased almost 4 times faster than in the Midwest and 1.4 times faster than in the United States. During 2004 to 2007, all technology groups in Northeast Ohio were growing faster than those in the Midwest and the

United States. Four NEO smaller technology groups grew faster than those in the United States and Midwest between 2006 and 2007 (Electronics, Energy and Power & Propulsion, Information and Communication, and Science & Engineering).

- ✓ In terms of 2007 productivity, the Energy and Power & Propulsion group generated the highest GRP per employee in Northeast Ohio (\$341,100), followed by Pharmaceuticals (\$212,500) and Advanced Materials (\$210,700). Six of the eight technology groups experienced a higher productivity growth rate in Northeast Ohio than in the Midwest and the United States between 2004 and 2007. These groups are: Advanced Manufacturing; Advanced Materials; Electronics; Energy and Power & Propulsion; Science and Engineering; Information and Communication; and Management, Sales & Facilities Support (the last group declined less than the Midwest). Five of them (the industries listed above except for Electronics) surpassed growth in the Midwest and the United States between 2006 and 2007.

## SUMMARY OF BIOSCIENCE SECTOR PERFORMANCE

- ✓ There were 12,739 employees in the bioscience sector in Northeast Ohio in 2007, with a gain of 230 employees, or 1.8%, since 2000 (Table II). NEO's bioscience employment grew at a slower rate (1.8%) over the 7-year period than in Ohio (6.4%) and in the United States (5.8%). The bioscience sector in Northeast Ohio is small, but it is growing and pays high average wages. Although it accounts for less than 1% of total employment in Northeast Ohio and 1.2% of total payroll, it experienced high rates of growth during the period from 2000 to 2007; the bioscience sector experienced gains while the total economy suffered losses or remained flat.

**Table II. NEO Bioscience Sector, 2007**

Segment	Employment	Payroll (\$)	Average Wages (\$)	Establishments	Average Establishment Size
Pharmaceuticals & Therapeutics	1,419	112,785,916	79,501	11	129.0
Agricultural Biotechnology	2,597	320,985,528	123,583	37	70.2
Medical Device & Equipment Manufacturers	5,453	262,779,680	48,187	115	47.4
Testing Laboratories	861	41,046,621	47,656	113	7.6
Research & Development	434	36,692,579	84,553	56	7.8
Medical Laboratories & Diagnostic Imaging Centers	1,974	213,262,492	108,036	201	9.8
<b>TOTAL NEO BIOSCIENCES</b>	<b>12,739</b>	<b>987,552,816</b>	<b>77,524</b>	<b>533</b>	<b>23.9</b>
<b>TOTAL NEO</b>	<b>1,999,668</b>	<b>80,783,662,862</b>	<b>40,399</b>	<b>105,834</b>	<b>18.9</b>

- ✓ The largest segments in NEO's bioscience sector are Medical Devices & Equipment Manufacturers and Agricultural Biotechnology. Three of the bioscience segments experienced employment gains (Pharmaceuticals & Therapeutics, Research & Development, and Medical Laboratories & Diagnostic Imaging Centers) and four segments had higher payroll between 2000 and 2007. This sector is projected to grow; regional initiatives to continue the growth in the

biosciences are very critical to build Northeast Ohio as one of the centers of excellence in the bioscience sector.

- ✓ Between 2005 and 2006, Northeast Ohio experienced remarkable growth of industry R&D funding (30% compared to a 9% growth in the rest of Ohio and 6% growth of industry R&D in the United States) mainly because R&D funding more than doubled in the Akron MSA. However, in 2006, industry R&D funding per employee in Northeast Ohio was just over half the amount for the remainder of the state, approximately 42% of R&D for the Midwest, and 47% for the nation.
- ✓ NEO's colleges and universities reported \$432.1 million in research expenditures in FY 2006 with Case Western Reserve University accounting for 86% of NEO's academic R&D expenditures. Although Northeast Ohio has experienced solid growth in academic R&D overall, the region again lags the state, the Midwest, and the United States in its level of funding when R&D expenditures are calculated per employee.

Several issues revealed in this report deserve attention by civic leaders and policy makers. Over the longer term (2000-2006), industry R&D funding in Northeast Ohio increased 9% in contrast to declines elsewhere in the state (-18%), in the Midwest (-6%), and in the United States (-5%).<sup>3</sup> Between 2006 and 2007, Northeast Ohio experienced remarkable growth of R&D funding of 30% compared to a 9% growth in the rest of Ohio and 6% growth of industry R&D in the United States.

The positive dynamic of last year's growth in industry and academic R&D should be reinforced and supported. Strongly associated with economic growth, the regional R&D capacity strengthens the base for growing productivity and GRP in the region. The significant increase of industry R&D in the Akron MSA and academic R&D at Case Western Reserve University and the Cleveland Clinic might create a base for reinforcement of R&D activity in the region.

Two large NEO technology groups, Advanced Manufacturing and Advanced Materials, displayed positive dynamics in their economic performance. Steady growth of Advanced Manufacturing, seen with a double-digit increase in GRP and productivity over 2004 to 2007, illustrates an example of a successful cluster composed of viable companies. A modest employment decline in the Advanced Materials group, paired with double-digit growth in productivity and wages during 2004 to 2007, identifies this cluster's strong economic position. Public policy directed to this cluster should consider the growing competition from other Midwest states and explore what contributes to their growth and the type of public policy support these industries receive.

Three other small but fast-growing technology groups—Energy and Power & Propulsion, Science and Engineering, and Electronics—deserve close attention from policy leaders. Together with the growing bioscience sector, these industries are building the core of a new regional economic structure in Northeast Ohio.

---

<sup>3</sup> Industry R&D funding at the regional level is estimated from state-level data. See methodology section for further detail. Funding is reported in 2007 dollars, adjusting for inflation.

## **INTRODUCTION**

This report presents the trend of the high-tech sector in Northeast Ohio (NEO) and compares it with the high-tech sector for the Midwest and the United States. This study presents high-tech sectors data for the period from 2004 to 2007 with a special highlight on the last-year change of 2006 to 2007. In addition to industry analysis, the report also analyzes research and development (R&D) for both industry and university using data from 2000 to 2006 (the most recent data available).

This study is an update of two previous reports commissioned by the Northeast Ohio Technology Coalition (NorTech) that examined the high-tech sector in Northeast Ohio. Four major perspectives are reflected in this year's analysis: (1) changes in overall high-tech trends in Northeast Ohio in comparison to the Midwest and the United States, (2) analysis of technology groups within the high-tech sector, (3) track of NEO research and development activity in industry and academia, and (4) detailed analysis of bioscience—a sector of the regional economy that corresponds to the BioOhio industrial cluster. This year's study includes an analysis of four indicators of high-tech: employment, average wages, gross regional product, and productivity. It looks at the absolute values of these indicators as well as their changes in 2007 in comparison to 2004 and 2006.

This report consists of five major parts. The first part includes an executive summary, this introduction, and a brief methodology section. The second part analyzes overall high-tech trends in Northeast Ohio in comparison to the Midwest and the United States. It also includes an analysis by sub-regions within Northeast Ohio (6 metropolitan areas and 8 non-metro counties combined). Northeast Ohio corresponds to the NorTech Service Area that includes 21 counties (Appendix A). The Midwest region is defined as an aggregation of six states including: Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. The third part of the report presents the analysis of eight technology groups within the 46-industry high-tech sector: Advanced Manufacturing; Advanced Materials; Pharmaceuticals; Electronics; Energy and Power & Propulsion; Information and Communication Technology; Management, Sales, & Facilities Support Services (primarily comprised of headquarters of companies); and Science & Engineering. Each of the 46 high-tech industries was assigned to one of the eight technology groups by NorTech. The performance of these groups is compared to the Midwest and U.S. groups that consist of the same industries. The fourth part of the report describes the bioscience sector in Northeast Ohio using the industrial definition of bioscience adopted by BioOhio. This section analyzes six segments within bioscience between 2000 and 2007 and compares Northeast Ohio to Ohio and the United States. The bioscience segments include Pharmaceutical & Therapeutics, Agricultural Biotechnology, Medical Device & Equipment Manufacturers, Testing Laboratories, and Medical Laboratories & Diagnostics Imaging Centers. The last part describes industry and academic R&D and compares Northeast Ohio to Ohio, the remainder of Ohio, the Midwest, and the United States. Both industry and academic R&D are examined from 2000 to 2006. Academic R&D expenditures are examined in terms of funding source and by academic institution.

### ***Relationship to the Dashboard of Economic Indicators***

This report complements the Dashboard of Economic Indicators project that is supported by the Fund for Our Economic Future (also a funding source of NorTech). The Dashboard Indicators project is an ongoing effort that tracks economic and social variables that are linked to economic growth. Data for 38 variables were collected for 136 metropolitan areas across the United States with populations between 300,000 and 3.5 million. Variables were then grouped statistically into nine factors; the factors associated with economic growth are referred to as Dashboard Indicators. The Dashboard Indicators include: Skilled Workforce and R&D, Technology Commercialization, Racial Inclusion & Income Equality, Urban Assimilation, Legacy of Place, Business Dynamics, Individual Entrepreneurship, Locational Amenities, and Urban/Metro Structure. Economic growth is measured in terms of employment, gross regional product (output), productivity, and per capita income.

This report builds on the Dashboard Indicators report by using the same four measures of economic growth. It also analyzes some of the same variables used in the Dashboard Indicators report that are relevant to the high-tech sector, such as industry and academic R&D funding. Yet it differs from the Dashboard Indicators project in terms of geographic focus. While the Dashboard Indicators project measures economic performance for metropolitan areas, including four in Northeast Ohio, this report defines Northeast Ohio as a 21-county area that includes both metropolitan and non-metropolitan counties. Since it is not a statistical region that can be compared to other regions in the country, this study compares Northeast Ohio to the national average and the average of Midwest states. Moreover, this study focuses only on the high-tech sector, while the Dashboard Indicators project addresses all sectors of the economy. Because of the more narrow focus of this study, it is possible to include an in-depth analysis of the individual industries that comprise the high-tech sector.

## METHODOLOGY

This study examines the high-tech sector in Northeast Ohio from four perspectives: an analysis of high-tech trends with a regional breakdown within Northeast Ohio, analysis of high-tech industries as eight technology groups, research and development activity, and in-depth analysis of the Northeast Ohio bioscience cluster. These analyses draw upon different data sets and emphasize different dynamics of the high-tech sector.

Northeast Ohio (NEO) is defined as a 21-county area to correspond to NorTech's service area. NEO consists of six metropolitan areas (Cleveland-Elyria-Mentor, Akron, Canton-Massillon, Mansfield, Sandusky, and Youngstown-Warren-Boardman) that encompass 13 metro and eight non-metro counties. The Cleveland metro area includes Cuyahoga, Geauga, Lake, Lorain, and Medina Counties; the Akron metro area includes Portage and Summit Counties; the Canton metro area includes Carroll and Stark Counties; the Mansfield metro area includes Richland County; the Sandusky metro area includes Erie County; and the Youngstown metro area includes Mahoning and Trumbull Counties.<sup>4</sup> The eight non-metro counties include Ashland, Ashtabula, Columbiana, Crawford, Holmes, Huron, Tuscarawas, and Wayne. A list of all NEO sub-regions and their counties is also included in Appendix A.

### ANALYSIS OF HIGH TECH INDUSTRIES

The industry analysis provided in this report (as well as two previous studies) utilizes a definition of high-tech industries offered by Daniel Hecker, an economist at the U.S. Bureau of Labor Statistics (BLS). Hecker identifies 46 four-digit NAICS industries as high-tech with the qualification that, "An industry is considered high-tech if employment in technology-oriented occupations accounted for a proportion of that industry's total employment that was at least twice the 4.9% average for all industries."<sup>5</sup>

This study includes two analyses based on the industry definition of high-tech: the changes in the high-tech sector as a whole and analysis of the 46 high-tech industries based on groupings by eight high-tech groups. The analysis of the overall trend of high-tech includes a comparison of the NEO high-tech sector to that of the Midwest and the United States. The dynamic of high-tech industries is compared to overall totals derived from all industries in employment, average wages, gross regional product, and productivity. As benchmarks, this analysis uses high-tech and total industries in the Midwest and the United States.

The analysis of the 46 high-tech industries according to the eight clusters is based on an industry assignment to a specific technology group identified by NorTech. This typology includes: Advanced Manufacturing; Advanced Materials; Pharmaceuticals; Electronics;

---

<sup>4</sup> This report excludes Mercer County, Pennsylvania, which is a part of the Youngstown MSA according to OMB definition of metropolitan areas.

<sup>5</sup> Daniel E. Hecker "High-technology employment: a NAICS-based update." *Monthly Labor Review*, pp. 57-72, July 2005.

Energy and Power & Propulsion; Information and Communication Technology; Management, Sales, and Facility Support Services (primarily comprised of headquarters of companies); and Science and Engineering.

Industry trends are examined for the 2004 to 2007 time period, with a special focus on the last-year changes (2006-2007). After recessionary declines between 2000 and 2004, total employment in Northeast Ohio began to increase in 2005 and kept growing through 2006. Data for 2007 show total employment in Northeast Ohio was still below the 2004 level. Following these trends, we established two time periods to use in our analysis; we use the 2004 to 2006 period to track gains in Northeast Ohio during the expansionary years and the 2006 to 2007 to monitor high-tech dynamics during the beginning of the period that experienced total employment decline. The analyses rely on data from two sources: the Quarterly Census of Employment and Wages (ES202) and Moody's economy.com. Employment and wage data are extracted from the ES202 database while the gross product and productivity data are extracted from Moody's Economy.com.<sup>6</sup>

Northeast Ohio is compared to the Midwest and the United States. The Midwest region is defined as an aggregation of six states: Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin. Employment trends are also analyzed for the sub-regions that comprise Northeast Ohio—the six metropolitan areas and the non-metro counties.

## **RESEARCH & DEVELOPMENT ANALYSIS**

The study examines research and development activity in the region by looking at industry R&D funding and R&D expenditures of academic institutions. In addition, some data are provided regarding the R&D activity of two other large research institutions in Northeast Ohio. Data on industry and academic R&D were obtained from the National Science Foundation (NSF) Division of Science Resources Statistics.

Industry R&D funding is only available at the state level. The level of funding in Northeast Ohio is estimated by distributing statewide funding according to each county's share of employment in one industry—Scientific Research and Development Services (NAICS 5417). This industry includes private sector companies with a primary function of research and development; therefore, employment levels are used to develop a proxy of industry R&D funding at the regional level. Employment counts for NAICS 5417 are derived from Moody's economy.com data.

Academic R&D expenditures are provided for individual institutions in Northeast Ohio that reported data to NSF. The latest data available for industry and academic R&D is 2006. R&D data for the other research intuitions (the Cleveland Clinic and NASA Glenn Research Center) were provided by the respective institutions.

---

<sup>6</sup> Employment data include all workers in high-tech industries — regardless of whether or not they are employed in high-tech occupations.

## BIOSCIENCE SECTOR ANALYSIS

This study describes the bioscience sector in Northeast Ohio using the definition adopted by BioOhio in their December 2007 report, *Ohio Bioscience Growth Report*.<sup>7</sup> BioOhio is a non-profit organization designed to build and accelerate bioscience industry, research, and education in Ohio. Bioscience includes six segments: Pharmaceuticals & Therapeutics, Agricultural Biotechnology, Medical Device & Equipment Manufacturers, Testing Laboratories, Research & Development, and Medical Laboratories & Diagnostic Imaging Centers.<sup>8,9</sup> Each of these segments is comprised of between one and ten industries at the six-digit NAICS definition.

The analysis in this section is different from the rest of this report in two ways: (1) a number of the bioscience industries are not included in the list of high-tech industries analyzed in the 1st and 2nd sections, and (2) the analysis of bioscience is based on six-digit industries, while the high-tech clusters and their respective industries are defined by four-digit NAICS. Consequently, some of the six-digit bioscience industries are included in the high-tech industries analyzed earlier, while others are not. Employment and other data on the bioscience sector cannot be added to the other high-tech industries because of potential duplications.

Four measures are utilized to analyze the bioscience sector: employment, payroll, average wages, and number of establishments. Trends in Northeast Ohio between 2000 and 2007 are compared to trends in Ohio and the United States, detailing two time periods, 2000 to 2004 and 2004 to 2007. Data from the Quarterly Census of Employment and Wages (ES202) are used.

---

<sup>7</sup> Ohio Bioscience Growth Report. BioOhio. December 2007. [www.bioohio.edu](http://www.bioohio.edu)

<sup>8</sup> The segments of Testing Laboratories and Research & Development include companies that are not bio-related. To capture only the bioscience portion of these segments, this report uses the same ratios that were used in the *Ohio Bioscience Growth Report*.

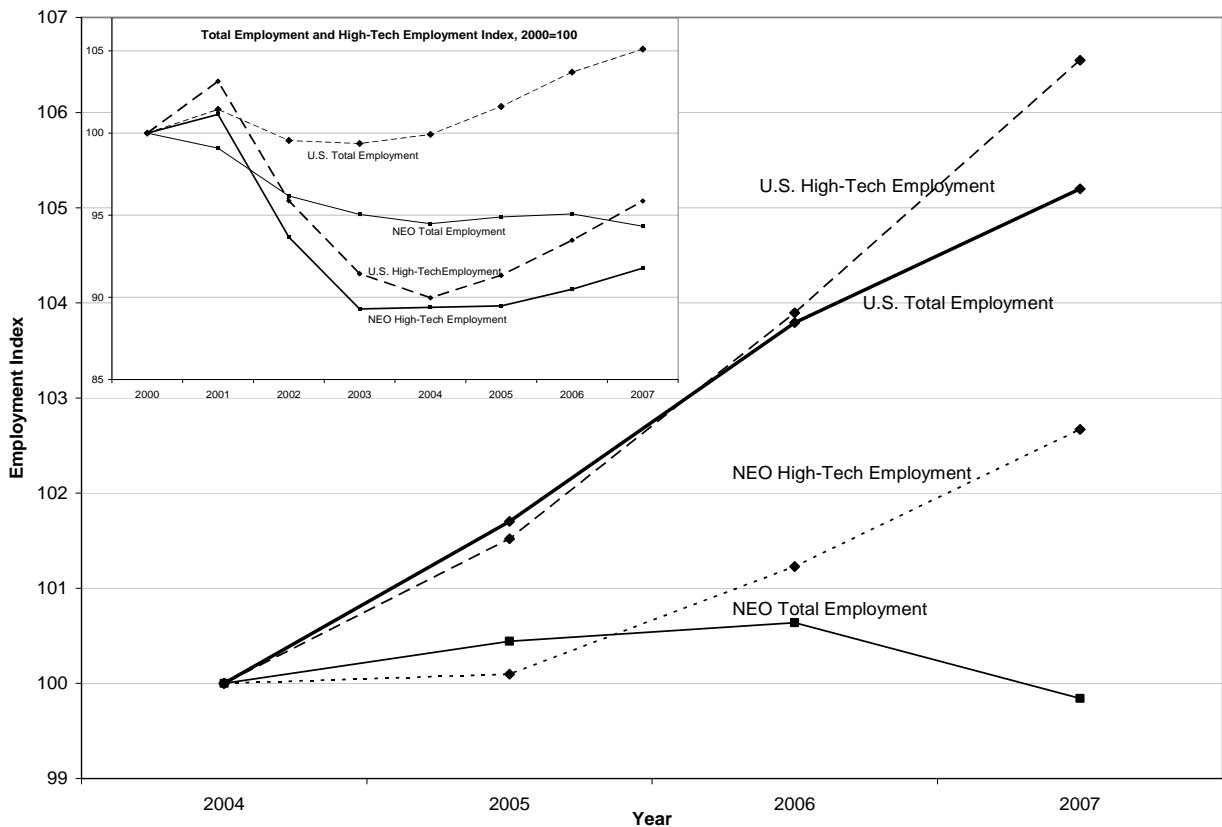
<sup>9</sup> The Ohio Bioscience report includes one additional segment, *Miscellaneous*, which includes information about ten specific companies throughout Ohio. We excluded this sub-category because only two of these companies are located in Northeast Ohio and confidentiality restrictions of our data sources preclude us from reporting data for less than three companies.

## HIGH-TECH INDUSTRIES: OVERALL TRENDS AND GEOGRAPHIC DISTRIBUTION

### EMPLOYMENT TRENDS

This section provides the analysis of high-tech industries showing the overall trend during the period from 2000 to 2007 with a focus on the 2004 to 2007 time period (Figure 1, Tables 1 and 2).

**Figure 1. Total Employment and High-Tech Employment Since 2004**  
Index, 2004=100



**Table 1. Total and High-Tech Employment in NEO and U.S., 2000-2007**

	2000	2001	2002	2003	2004	2005	2006	2007
U.S. All Industries	126,837,335	128,659,467	126,264,225	126,023,846	126,730,069	128,889,163	131,534,435	133,316,981
U.S. High-Tech Industries	13,259,140	13,677,024	12,712,020	12,123,800	11,929,159	12,110,502	12,393,790	12,710,602
NEO All Industries	2,119,866	2,100,351	2,038,674	2,014,889	2,002,830	2,011,699	2,015,606	1,999,668
NEO High-Tech Industries	185,896	188,016	174,119	165,995	166,166	166,327	168,207	170,602

**Table 2. Total and High-Tech Employment in NEO and U.S., Percentage Change**

	2000-2004	2004-2006	2006-2007	2004-2007	2000-2007
U.S. All Industries	-0.1	3.8	1.4	5.2	5.1
U.S. High-Tech Industries	-10.0	3.9	2.6	6.6	-4.1
NEO All Industries	-5.5	0.6	-0.8	-0.2	-5.7
NEO High-Tech Industries	-10.6	1.2	1.4	2.7	-8.2

During the last year, 2006 to 2007, total NEO employment reversed its 2004 to 2006 growth trend and declined. The decline was less than 1% (-0.8%), reflecting the loss of almost 16,000 jobs (15,938). This decline is the only negative trend among all four measures presented in Figure 1.<sup>10</sup> By contrast, NEO high-tech employment grew by 1.4% (2,395 jobs) between 2006 and 2007 (Tables 1 and 2). Both measures of employment lagged the national trends; the U.S. economy added 1.4% to employment for all jobs and the U.S. high-tech sector grew by 2.6% from 2006 to 2007.

Comparison between the longer term trends of high-tech employment between Northeast Ohio and the United States reveals three distinct periods between 2000 and 2007. Both for the United States and Northeast Ohio, high-tech employment was still growing between 2000 and 2001. In 2002, the U.S. high-tech employment and NEO high-tech employment levels started falling, but the length of the declining period for the two geographies was different. The NEO high-tech industries stopped declining in 2 years and started adding employment again in 2004. The U.S. high-tech industries were still declining through 2004 and did not start growing again until 2005.

Although both Northeast Ohio and the United States went through similar phases of high-tech employment dynamics, the rates of growth and decline were significantly different. Over the entire time period between 2000 and 2007, Northeast Ohio lost high-tech employment at a faster rate than the United States and recovered more slowly when compared to the United States. During 2000 to 2001, the national economy was still growing when Northeast Ohio was losing total employment. During the same time period, U.S. high-tech industries grew by 3.2%, compared to NEO high-tech employment growth of only 1.1%. These two facts together indicate that the U.S. economy was changing its structure, having a larger presence of the high-tech sector earlier and at a much faster rate than Northeast Ohio. Following the employment decline between 2001 and 2003/2004, the growth in both geographies resumed; U.S. high-tech added 6.6% employment from 2004 to 2007 (about 2.2% a year), while Northeast Ohio grew only 2.8% between 2003 and 2007 (about 0.7% annually). Although the NEO growth rate was lower compared to the United States, in 2006-2007 it accelerated at a faster rate in comparison to the 2 previous years.<sup>11</sup>

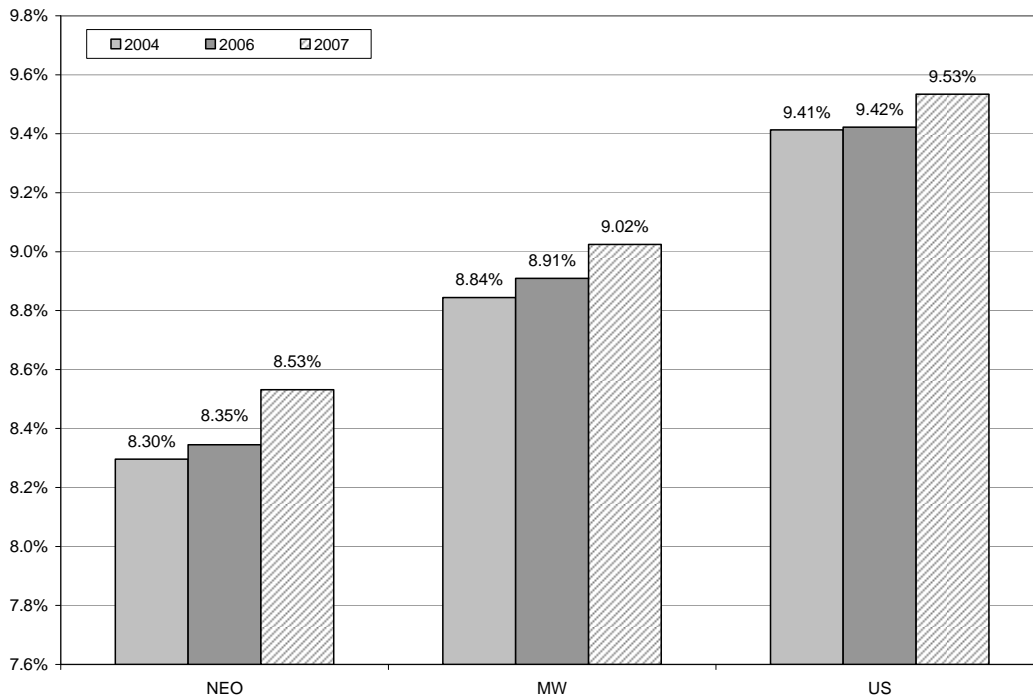
<sup>10</sup> In Figure 1 the employment index for every year is calculated as the change from 2004, where 2004 is the base year and is equated to 100. In the reference figure included in Figure 1, the employment index is calculated as the change from 2000, where 2000 is the base year and is equal to 100.

<sup>11</sup> During 2004-2006, U.S. high-tech industries grew 3.9% (or about 1.95% annually), which averages out to a 0.65 percentage point annual acceleration. The NEO high-tech sector grew 1.2% from 2004 to 2006 (average of 0.6% annually) followed by a 0.8 percentage point acceleration in 2006-2007. The greater increase of NEO high-tech employment growth rate illustrates that, percentage-wise, the region is increasing its high-tech employment growth rate faster during the last 3 years (2004-2007). The high-tech employment growth rate difference between Northeast Ohio and the United States was 2.7% in 2004-2006; it is reduced to 1.2% in 2006-2007.

Taking into account the last-year changes in NEO total employment and NEO high-tech employment, we must emphasize that growing the high-tech sector in a declining regional economy requires greater effort compared to an economy with overall growth across different sectors. With a NEO total employment decline of less than 1% (-0.8%), the growth of the high-tech sector employment at 1.4% is an important accomplishment. From 2006 to 2007, NEO high-tech employment was growing even slightly higher than the average of the high-tech employment of all Midwest states (1.42% compared to 1.29%). This is remarkable considering that the total employment in the Midwest was virtually unchanged (0.002%) (Appendix B, Figure B-1).

Not only is the employment in the high-tech sector growing, the share of NEO high-tech employment in total regional employment is growing as well. However, the increase of the high-tech share is a result of high-tech industries growth and the decline of total employment. Since 2004, the share of high-tech employment in total employment is consistently growing for all three geographical levels—Northeast Ohio, the Midwest and the United States (Figure 2). Although the difference between the highest and the lowest high-tech employment shares is less than 2 percentage points, NEO’s share is lagging against both benchmark regions in all years. Compared to 2004, NEO high-tech employment share grew 0.23 percentage points, reaching 8.53% in 2007. This increase is due not only to the growth of high-tech sector employment, but also the decline of NEO’s total employment. The growth of the high-tech employment share in Northeast Ohio was higher than in the Midwest (0.18 percentage point) and the United States (0.12 percentage point). By 2007, the share of the high-tech employment in the Midwest and the United States were 9.02% and 9.53%, respectively.

**Figure 2. High-Tech Employment Share: NEO, Midwest and U.S., 2004 to 2007**



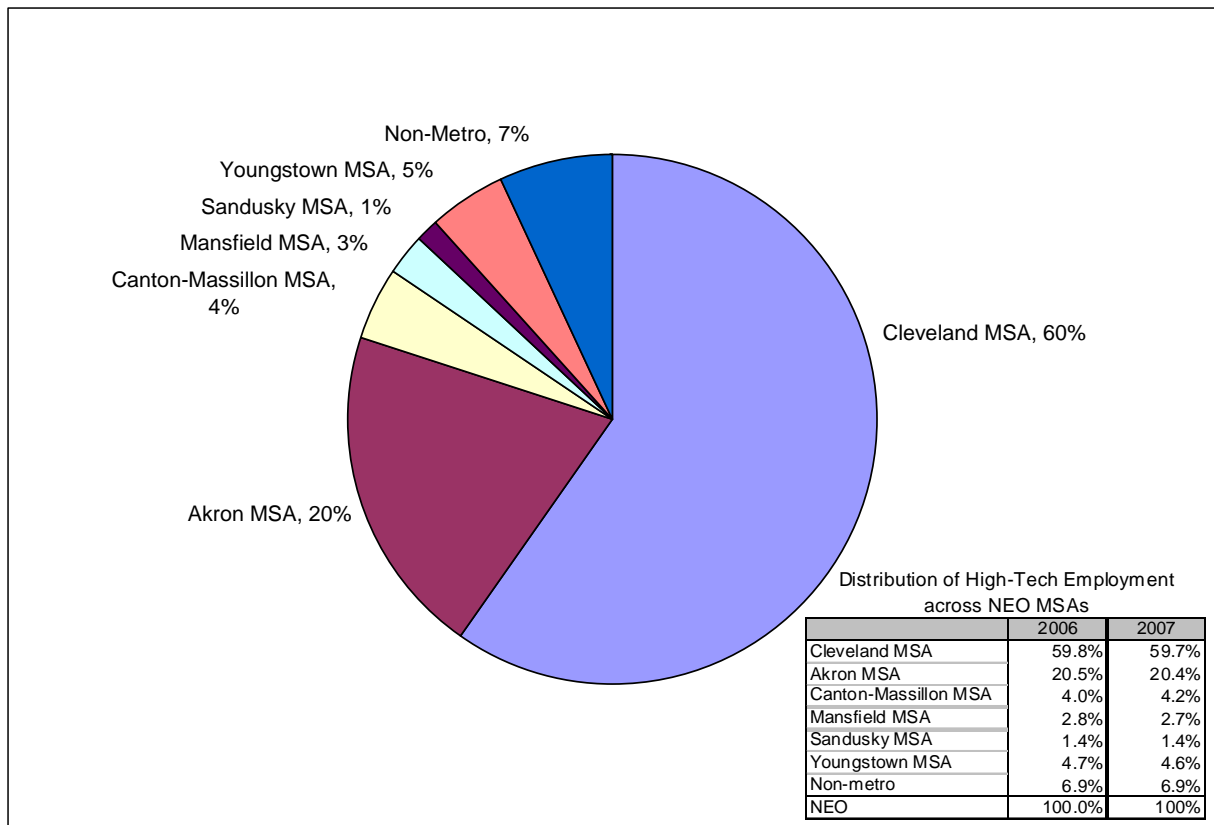
Overall, NEO high-tech employment has been growing consistently since its lowest level in 2003 and the percentage growth during the last 3 years, 2004 to 2007, is accelerating. However, even at the existing annual growth rate of 1.4% from 2006 to 2007, the growth rate in Northeast Ohio falls far short of the growth rate in the United States, which was 2.6% for the same period.

To achieve the same growth rate in high-tech employment as in the Midwest, Northeast Ohio would have had to increase high tech employment by a total of 5,995 jobs - approximately 1,500 more jobs than recorded. To achieve the same growth rate as in the United States, Northeast Ohio would have had to increase high tech employment by a total of 10,885, as opposed to 4,436—approximately 6,500 more.

### EMPLOYMENT IN NEO’S SUB-REGIONS

Northeast Ohio includes six metropolitan areas and several rural counties. The distribution of high-tech employment across these geographies illustrates that, in 2007, four larger metropolitan areas—Cleveland-Elyria-Mentor, Akron, Youngstown, and Canton-Massillon—together account for 85% of all NEO high-tech employment. The Cleveland-Elyria-Mentor MSA captured the largest share of NEO high-tech employment, holding at 59.7% for the past 2 years. (Figure 3.)

**Figure 3. Total High-Tech Employment by MSA, 2007**



There were no significant changes in the high-tech intensity of each metro area's labor market in 2007 compared to 2006. Akron retains the highest concentration of high-tech jobs, where almost 11% of its total employment is in high-tech industries, meaning that every 9th worker is employed by the high-tech sector (Table 3). By comparison, the Cleveland MSA increased its share of high-tech employees to 9.9% (compared to 9.7% in 2006) and, together with Akron, represent the only geographies in Northeast Ohio that have a high-tech employment share higher than that of the Midwest (9.02%) and the average of the United States (9.53%). Two smaller metro areas, Mansfield and Sandusky, increased their high-tech employment shares by 0.1 percentage point each primarily due to losses of employment in other industries and a decline of total employment.

Overall, Northeast Ohio added 2,395 high-tech jobs while it lost more than 18,300 in other economic sectors between 2000 and 2007. All areas, except for the Mansfield and Youngstown MSAs added high-tech employment between 2006 and 2007. Cleveland added the most high-tech jobs in 2007 (1,272) while losing close to 7,000 jobs in other sectors, thus raising its share of high-tech employment from 9.7% to 9.9%. Akron and Canton added 428 and 484 high-tech jobs, respectively; the non-metro areas added 271 high-tech jobs.

The Canton MSA yielded the highest 2007 rate of growth in the high-tech sector compared to the two previous years (6.7% growth compared to a decline of 4.3% in 2004-2006) (Figure B-2 in Appendix B). Two of the largest metro areas, Cleveland and Akron, maintained their high-tech growth rates at 1.2% each. This reflects an additional 1,700 high-tech jobs for Northeast Ohio in 2007. NEO non-metro counties lost 4,633 jobs in non-tech industries and added 271 employees in high-tech sectors of their economies in 2007.

**Table 3. High-Tech Employment Share: NEO Metropolitan Areas, 2006-2007**

MSA/county	2006			2007		
	High-Tech	Total	Share (%)	High-Tech	Total	Share (%)
Cleveland MSA	100,561	1,032,510	9.7	101,833	1,026,949	9.9
Akron MSA	34,454	319,004	10.8	34,882	319,965	10.9
Canton-Massillon MSA	6,687	165,745	4.0	7,170	165,526	4.3
Mansfield MSA	4,658	57,030	8.2	4,629	55,975	8.3
Sandusky MSA	2,354	35,307	6.7	2,363	34,965	6.8
Youngstown MSA	7,945	185,894	4.3	7,906	180,535	4.4
Non-Metro counties	11,548	220,115	5.2	11,819	215,753	5.5
NEO	168,207	2,015,606	8.3	170,602	1,999,668	8.5
U.S.	12,393,790	131,534,435	9.4	12,710,602	133,316,981	9.5

## AVERAGE WAGE TRENDS

In 2007, the average wage for high-tech jobs in Northeast Ohio was almost \$71,000. NEO high-tech industries were not only growing in the number of jobs, but on average high-tech jobs were paying higher salaries than in 2006, after adjusting for inflation. In

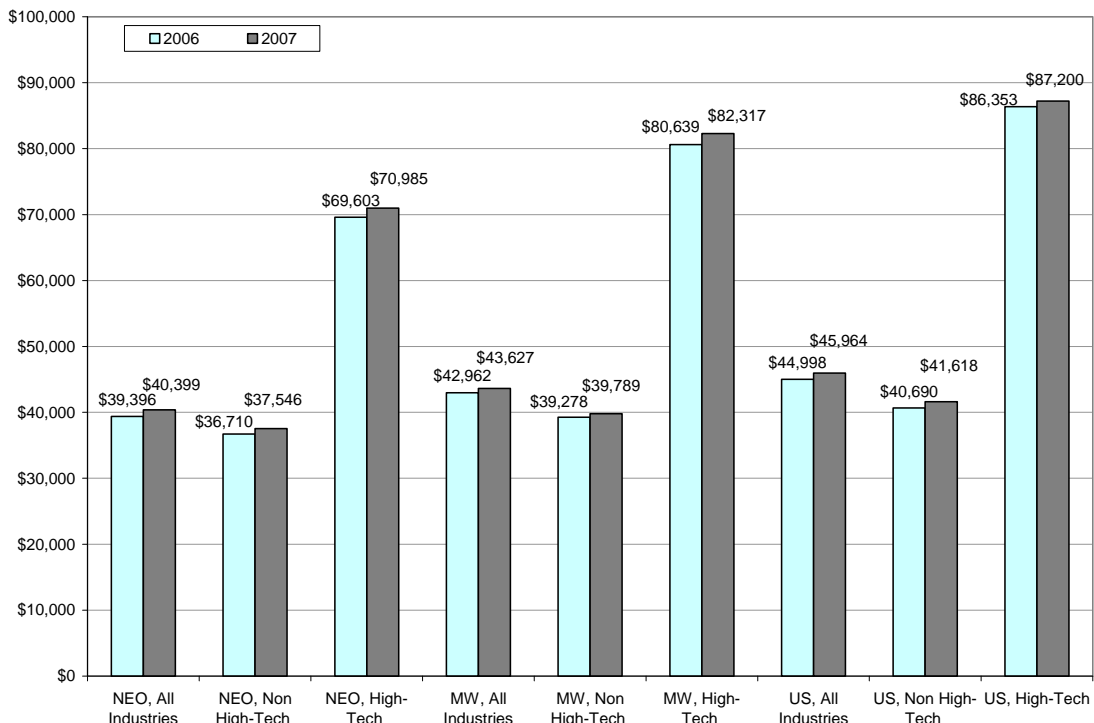
2006, the average wage in high-tech industries was \$69,603 compared to \$70,985 in 2007 (Figure 4). In 2007, the average wage in high-tech industries was 89% higher than the average wage for non-high-tech industries.

The average wage in Northeast Ohio continues to be lower than in the Midwest and the United States in both high-tech and non-high-tech industries. As in previous years, the gap between the average wages in high-tech industries is much larger. Average wage in Northeast Ohio lags the Midwest in non-high-tech industries by 6% in 2007, which shows a small improvement compared to a 7% difference in 2006. From 2006 to 2007, the NEO average wage in the non-high-tech sector was growing faster than in the Midwest and at about the same rate of growth of the average U.S. non-high-tech wages.

NEO average wages lagged behind U.S. average wages significantly more than the Midwest did. In 2007, the Midwest average wage in all industries was lagging the U.S. average wage by only 5.4%; the difference in the average wage in high-tech industries was 5.9%. Northeast Ohio lagged the United States in all industries' average wages by 13.8%, while the high-tech industries' wages were lagging the United States by 22.8%.

From 2006 to 2007, the average wages of NEO high-tech industries were growing almost at the rate of the Midwest. NEO wages narrowed the gap with the average high-tech wages in the United States by 1.3 percentage point; 2006 NEO average high-tech wages were lagging the U.S. average by 24.1%, which decreased to 22.8% in 2007. This still reflects a difference of \$16,215 a year between the average wages of \$70,985 in NEO high-tech sector and the U.S. average of \$87,200. NEO wages were \$11,332 less than the average Midwest worker for the high-tech sector.

**Figure 4. Average Wages in High-Tech, Non-High-Tech and All Industries: NEO, the Midwest and U.S., 2006 and 2007**



The gap between U.S. high-tech wages and NEO high-tech wages may reflect a prevalence of lower-end high-tech jobs in Northeast Ohio as well as a different cost of living. However, the adjustment for the lower cost of living in Northeast Ohio constitutes only a small reduction of average wages compared to the national average (using CPI-U index as a base for the adjustment). Assuming that Northeast Ohio has the same mix of industries as the United States and adjusting for the difference in cost of living, NEO average wages across all industries should have been \$43,372 in 2007 and NEO high-tech average wages should have been \$82,282. Existing average wages lagged these targets by \$2,971 for all industries and by \$11,297 for high-tech industries.

## HIGH-TECH INDUSTRIES BY TECHNOLOGY GROUP

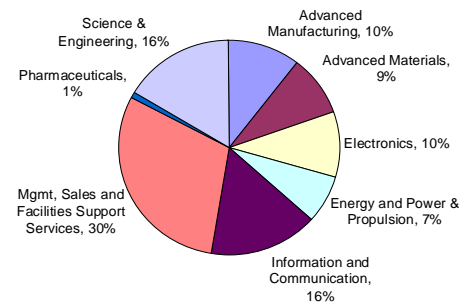
This section analyzes high-tech industries in terms of employment, average wages, and gross regional product for the high-tech sector as a whole, as well as eight technology groups that are prominent in Northeast Ohio. Table B-1 in Appendix B provides the list of industries by technology group. Again, Northeast Ohio is compared to the Midwest and the United States.

### EMPLOYMENT BY TECHNOLOGY GROUP

**Table 4. NEO Employment by Technology Group, 2007**

Technology Group	Emp	Employment Change		
	2007	2004-2006	2004-2007	2006-2007
Advanced Manufacturing	17,816	795	949	154
Advanced Materials	15,841	-520	-843	-323
Electronics	16,435	-140	-55	85
Energy and Power & Propulsion	12,552	38	497	460
Information and Communication	26,844	N/A	N/A	1,469
Management, Sales & Facilities Support	51,624	-915	-1,359	-443
Pharmaceuticals	1,419	N/A	N/A	38
Science & Engineering	28,071	2,414	3,369	956
<b>Total High-Tech Employment</b>	<b>170,602</b>	<b>2,041</b>	<b>4,436</b>	<b>2,395</b>
<b>Total Employment, all industries</b>	<b>1,999,668</b>	<b>12,776</b>	<b>-3,162</b>	<b>-15,938</b>

Distribution of Employment by Technology Group: NEO, 2007



**Table 5. Employment Share by Technology Group: NEO, the Midwest and U.S., 2004-2007**

Technology Group	Share of Total Employment, 2004 (%)			Share of Total Employment, 2006 (%)			Share of Total Employment, 2007 (%)		
	NEO	MW	U.S.	NEO	MW	U.S.	NEO	MW	U.S.
Advanced Manufacturing	0.84	0.74	0.42	0.88	0.74	0.41	0.89	0.74	0.41
Advanced Materials	0.83	0.41	0.38	0.80	0.40	0.35	0.79	0.40	0.34
Electronics	0.82	1.03	1.17	0.81	1.00	1.13	0.82	1.00	1.10
Energy and Power & Propulsion	0.60	0.76	1.02	0.60	0.76	1.01	0.63	0.76	1.02
Information and Communication	N/A	1.68	2.19	1.26	1.67	2.14	1.34	1.78	2.22
Mgmt, Sales & Facilities Support	2.65	2.19	1.96	2.58	2.23	1.97	2.58	2.25	1.99
Pharmaceuticals	N/A	0.26	0.23	0.07	0.25	0.22	0.07	0.25	0.22
Science & Engineering	1.23	1.77	2.04	1.35	1.86	2.20	1.40	1.85	2.24
<b>Total High-Tech Employment</b>	<b>8.30</b>	<b>8.84</b>	<b>9.41</b>	<b>8.35</b>	<b>8.91</b>	<b>9.42</b>	<b>8.53</b>	<b>9.02</b>	<b>9.53</b>
<b>Total Employment, all Industries</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>	<b>100.00</b>

Analyzing the high-tech sector in Northeast Ohio by eight technology groups (Tables 4 and 5) reveals that the largest group is Management, Sales, and Facilities Support (primarily comprised of companies' headquarters),<sup>12</sup> accounting for 30% of all jobs in high-tech industries. Other large technology groups are Science & Engineering<sup>13</sup> (16%) and Information and Communication<sup>14</sup> (16%). The next three largest groups, Advanced Manufacturing,<sup>15</sup> Electronics,<sup>16</sup> and Advanced Materials,<sup>17</sup> combined, account for 29% of high-tech employment.

Although there was net growth for the NEO high-tech sector, two groups lost employment over the last year. The largest group, Management, Sales, and Facilities Support, lost 443 employees (-0.9%) while Advanced Materials lost 323 jobs (-2%) (Appendix B, Table B-1 and Figures B-3 and B-4). Both groups have been continuously losing employment since 2004. All other technology groups gained employment, led by two groups that accounted for 77% of the total job growth in high-tech industries: the Information and Communication sector gained 1,469 employees (5.8% growth from 2006) and Science and Engineering added 956 jobs (3.5% gain from 2006). Another important technology group, Energy and Power & Propulsion,<sup>18</sup> added 460 jobs (3.8% growth) in 2007, strengthening the high priority sector of NEO economic development in green energy technologies.

Compared to the averages of the Midwest and United States, five NEO technology groups showed advanced employment growth (Appendix Table B-1). Between 2004 and 2007, Advanced Manufacturing grew by 5.6% in Northeast Ohio compared to 1.6%

---

<sup>12</sup> The Management, Sales, and Facilities Support group includes headquarters of companies, wholesale, financial and support service industries. This group accounts for such companies as PartsSource, Inc., ASI Investment Holding Co., Associated Materials Inc., and Siemens Medical Solutions USA, Inc.

<sup>13</sup> The Science and Engineering group includes industries that are comprised of architectural, engineering, consulting companies, and companies providing scientific R&D services. This sector accounts for such companies as Middough Consulting Inc., Zin Technologies, Inc., Ricerca Biosciences LLC, Accenture Llp., and McKinsey and Co., Inc.

<sup>14</sup> The Information and Communication Technology group includes industries manufacturing audio, video and optical equipment, publishing, telecommunication carriers, and services in data processing and computer design. These industries account for such companies as Qudax Inc., Hyland Software Inc., Intuit Inc., Oracle Corp., and Brulant Inc.

<sup>15</sup> The Advanced Manufacturing group includes four industrial machinery and transportation equipment manufacturing industries. It accounts for companies such as Lincoln Electric Co., Parker Hannifin Corporation, Gorman-Rup Co., FMC Foodtech Inc., Demag Cranes & Components Corp., and Hydromatic Pumps Inc.

<sup>16</sup> The Electronics group is comprised of five computer and electronic equipment manufacturing industries and an industry that repairs electronic equipment. This group of industries is represented, among others, by Keithley Instruments Inc., Rockwell Automation Inc., Apsco Inc., Therm-O-Disc Inc., and Emerson Network Power, Energy Systems, North America Inc.

<sup>17</sup> The Advanced Materials Group includes five manufacturing industries that are part of the chemical products cluster. These industries include companies such as Day-Glo Color Corporation, Lubrizol Corporation, PolyOne Corp., Henkel Adhesive Technologies, PPG Industries Inc., and Sherwin-Williams Automotive Finishes Corporation.

<sup>18</sup> The Energy and Power & Propulsion group includes industries that extract, manufacture equipment, and transport energy and power resources. Among companies representing this group are Parker Hannifin Corp. Airborne Division, CertainTeed Corp., Aircraft Braking Systems Corp., and TransDigm Group Inc.

in the Midwest and 2.1% in the United States. NEO's growth in Pharmaceuticals also surpassed both the Midwest and the United States, and NEO's performance in Electronics showed less decline compared to both benchmark geographies (-0.3% in Northeast Ohio compared to -1.3% in the Midwest and the United States). The Electronics group is also of particular note because from 2006 to 2007 it added 85 jobs (0.5%) in Northeast Ohio, yet this group declined in the Midwest (-0.6%) and in the United States (-1.2%). This group is remarkable because it also reversed its declining trend (-0.9% in 2004-2006) to growth in 2007. Energy and Power & Propulsion increased its growth from 0.3% for the 2 previous years to 3.8% for the last year while Information and Communication also experienced growth rate increase from 0.3% for 2004 to 2006 to 5.8% in 2006 to 2007. Although the Information and Communication Group was also growing in the Midwest and the United States, the NEO rate of growth surpassed both benchmarking geographies in 2006 to 2007. The Energy and Power & Propulsion Group, in contrast to Northeast Ohio, declined both in the Midwest and the United States in 2006 to 2007 compared to 2004 to 2006.

Employment in NEO's high-tech industries as a share of total employment increased from 8.35% to 8.53% between 2006 and 2007. This growth might appear slight, yet it has significantly accelerated when compared to the previous 2-year increase of 0.05 percentage point from 2004 to 2006. Northeast Ohio, the Midwest, and the United States all experienced increased shares of employment in high-tech industries between 2004, 2006 and 2007 (Table 5).

In 2007, Northeast Ohio held a higher share of high-tech employment than the Midwest and the United States in the following technology groups: Advanced Manufacturing; Advanced Materials; and Management, Sales, & Facilities Support Services. In 2007 the largest NEO high-tech group—Management, Sales, & Facilities Support Services—retained its share in total employment at 2.58%; but the two other groups dropped their shares very slightly (0.01 percentage point each) compared to 2006 and even more so compared to 2004. The Advanced Manufacturing and Advanced Materials groups still held a significantly larger share in NEO's economy than they did in the Midwest and the United States. Information and Communication Technology; Management, Sales & Facilities Support Services; and Science and Engineering continue to be the three technology groups with the highest share of employment in Northeast Ohio, the Midwest and the United States.

Advanced Manufacturing and Advanced Materials technology groups are important base industries for the NEO economy. Also, being a base industry in the Midwest, Advanced Materials added jobs in this group between 2006 and 2007 (1.7%) while Northeast Ohio and the United States experienced job losses (-2% and -1.6%, respectively). Three more technology groups added jobs and increased their shares in NEO's total employment during the last year: Energy and Power & Propulsion, Information and Communication, and Science and Engineering. Even with such positive dynamics, these industries have significantly smaller shares of their employment in total employment and they are not base industries for NEO.

## AVERAGE WAGES, GROSS REGIONAL PRODUCT AND PRODUCTIVITY BY TECHNOLOGY GROUP

Average wages for high-tech industries in Northeast Ohio, the Midwest, and the United States in 2007 were significantly higher than the average wage for all industries (Table 6). The highest average wage in Northeast Ohio was paid by Management, Sales, and Facilities Support Services (\$89,729). The average wage in this group experienced the largest increase over the last 3 years (23.2%), although it was closing the gap with the Midwest and the United States over the last year more slowly (3.3%).

The highest wages in the Midwest and the United States were paid in the Pharmaceuticals group (\$119,916 and \$120,548, respectively); this group ranked second highest in NEO wages (\$79,501).<sup>19</sup> The wages in this industry grew much faster in the Midwest and the United States than in Northeast Ohio over the last 3 years. In 2007, NEO pharmaceuticals wages were falling while the Midwest and U.S. wages continued to grow with the Midwest almost reaching the level of U.S. wages in this group.

Only the Advanced Materials group paid average wages in Northeast Ohio higher than that in the Midwest and the United States (\$77,481, compared to \$73,155 and \$76,001, respectively). Average wages in this sector increased 11% for Northeast Ohio over the last year, the highest growth of all groups in Northeast Ohio and the highest growth among all technology groups in the Midwest and the United States.

Advanced Manufacturing average wages grew 6.1% in 2004 to 2006, but fell by -3.2% over the last year for a total 3-year growth of 2.9%. This growth helped to close the gap with average wages in the Midwest and the United States (1.7% and 2.0%, respectively).

**Table 6. Average Wage by Technology Group: NEO, the Midwest and U.S., 2004-2007**

Technology Group	2007 (\$)			Percentage Change					
				2004-2007			2006-2007		
	NEO	MW	U.S.	NEO	MW	U.S.	NEO	MW	U.S.
Advanced Manufacturing	51,343	56,778	58,598	2.9	1.7	2.0	-3.2	-0.4	-0.4
Advanced Materials	77,481	73,155	76,001	17.9	9.3	6.1	11.0	0.7	1.7
Electronics	55,102	61,075	81,997	9.9	1.6	3.7	3.1	-1.9	-4.8
Energy and Power & Propulsion	73,961	91,965	95,312	15.3	12.3	9.0	-0.7	0.1	-0.7
Information and Communication	63,141	77,269	80,676	N/A	4.6	-0.7	-0.8	1.1	-5.1
Mgmt, Sales and Facilities Support	89,729	104,771	101,384	23.2	9.3	12.9	3.3	6.3	5.3
Pharmaceuticals	79,501	119,916	120,548	N/A	22.5	13.8	-1.2	8.5	6.2
Science & Engineering	60,355	74,519	76,800	4.0	2.5	7.4	0.1	-0.4	2.2
Average of all High-Tech Wages	70,985	82,317	87,200	12.2	6.8	7.2	1.9	2.2	0.9
Average Wage, all Industries	40,399	43,627	45,964	5.7	4.5	6.2	3.0	1.6	2.1

<sup>19</sup> The Pharmaceuticals group is represented by the Pharmaceutical industry. Ben Venue Laboratories Inc. is an example of NEO companies included in this industry.

Two more technology groups were trying to catch up in average wages with the Midwest and the United States over the last 3 years. Energy and Power & Propulsion grew faster than the Midwest and the United States in 2004 to 2007 (15.3% compared to 12.3% and 9.0%, respectively). Electronics increased their average wages 10% over the last 3 years, growing almost 3 times faster than the United States and 5 times faster than the Midwest. Between 2006 and 2007, the Electronics group increased their wages by 3.1%, while both the Midwest and the United States declined (-1.9% and -4.8%, respectively).

Science and Engineering wages were growing 4% during 2004 to 2007, surpassing the Midwest (2.5%), but not reaching the average wages growth in the United States (7.4%). Both Northeast Ohio and the Midwest lagged the United States in average wages in this group in 2007 (0.1% and -0.4% compared to 2.2%, respectively).

Between 2004 and 2007, the gross regional product (GRP) generated by high-tech industries in Northeast Ohio increased almost 4 times faster than in the Midwest and 1.4 times faster than in the United States (Table 7). During 2004 to 2007, all technology groups in Northeast Ohio were growing faster than those in the Midwest and the United States (Appendix B, Table B-2). Four NEO smaller technology groups grew faster than the United States and Midwest between 2006 and 2007 (Electronics, Energy and Power & Propulsion, Information and Communication, and Science & Engineering). Two major high-tech manufacturing groups, Advanced Manufacturing and Advanced Materials were also growing, although at a slower pace than during 2 previous years. Advanced Manufacturing (4.1%) surpassed the Midwest (1.7%) but not quite reaching the U.S. growth (4.7%). Advanced Materials grew by 2.0% in Northeast Ohio compared to a minimal growth in the United States (0.1%), but at half the growth rate in the Midwest (4.2%).

Moreover, the three largest technology groups—Advanced Manufacturing; Advanced Materials; and Management, Sales, & Facilities Support Services—kept their shares in total GRP since 2006 and increased them from 2004 by 0.1 percentage point each. These three groups have the largest shares in the total GRP in Northeast Ohio compared to the Midwest and United States (Appendix B, Table B-3).

**Table 7. GRP by Technology Group: NEO, the Midwest and U.S., 2004-2007**

Technology Group	GRP 2007 (in million \$)			Percentage Change					
				2004-2007			2006-2007		
	NEO	MW	U.S.	NEO	MW	U.S.	NEO	MW	U.S.
Advanced Manufacturing	1,561	18,592	61,582	15.4	8.3	8.9	4.1	1.7	4.7
Advanced Materials	2,884	19,849	109,730	7.4	2.5	-0.4	2.0	4.2	0.1
Electronics	1,758	22,003	174,501	17.6	9.4	7.8	3.1	1.4	2.9
Energy and Power & Propulsion	4,736	58,386	537,094	23.3	11.7	18.0	6.8	2.2	2.0
Information and Communication	3,839	67,342	563,210	9.3	3.5	4.5	5.9	1.4	0.2
Mgmt, Sales & Facilities Support	6,615	75,255	386,587	1.5	-7.4	-0.3	-1.7	-1.9	1.1
Pharmaceuticals	418	20,357	98,759	25.8	4.8	15.7	-3.8	4.0	5.9
Science & Engineering	3,200	58,743	410,356	19.3	8.6	15.5	2.3	0.5	2.1
Total High-Tech GRP	25,011	340,527	2,341,820	11.6	3.2	8.4	2.6	0.8	1.6
Total GRP, all Industries	172,329	2,231,334	13,633,925	4.9	4.2	7.8	1.2	1.3	1.6

In terms of 2007 productivity, the Energy and Power & Propulsion group generated the highest GRP per employee in Northeast Ohio (\$341,100) followed by Pharmaceuticals (\$212,500) and Advanced Materials (\$210,700) (Table 8). NEO has higher productivity levels than the Midwest in two of the eight technology groups: Electronics (25% higher) and Management, Sales & Facilities Support (7.3% higher). NEO's productivity exceeds the United States only in Management, Sales & Facilities Support (12.8%). Moreover, productivity in Northeast Ohio grew faster in most of the technology groups. Six of the eight technology groups experienced a higher productivity growth rate in Northeast Ohio than in the Midwest and the United States between 2004 and 2007; five of them surpassed growth in the Midwest and the United States between 2006 and 2007 (Appendix B, Figure B-5).

**Table 8. Productivity by Technology Groups, NEO, the Midwest and U.S., 2004-2007**

Technology Group	2007 (in thousand \$)			Percentage Change					
				2004-2007			2006-2007		
	NEO	MW	US	NEO	MW	US	NEO	MW	US
Advanced Manufacturing	102.1	121.5	110.8	9.5	7.9	5.3	3.3	3.0	2.9
Advanced Materials	210.7	219.3	237.7	11.6	5.2	3.9	5.2	4.4	0.6
Electronics	105.2	84.2	116.6	21.0	11.3	7.9	-0.4	2.1	3.4
Energy and Power & Propulsion	341.1	352.7	423.0	30.7	9.4	10.9	8.4	1.5	-0.8
Information & Communication	152.8	173.2	193.4	N/A	1.4	-0.2	1.6	0.3	-2.3
Mgmt, Sales & Facilities Support	97.6	91.0	86.5	-4.4	-10.0	-1.9	-2.5	-1.3	0.4
Pharmaceuticals	212.5	365.1	331.9	N/A	9.6	12.9	-11.8	6.1	4.1
Science & Engineering	121.5	135.1	134.8	6.7	2.3	-1.4	3.4	0.3	-2.7
Total High-Tech Productivity	138.3	140.8	155.5	6.8	0.9	3.3	1.7	1.0	-0.3
Total Productivity, all Industries	88.7	95.1	96.6	4.6	2.8	2.8	1.2	1.1	0.4

## THE BIOSCIENCE SECTOR IN NORTHEAST OHIO

The NEO bioscience sector analysis is based on the definition of the bioscience sector adopted by BioOhio. The bioscience sector includes six segments: Pharmaceuticals & Therapeutics, Agricultural Biotechnology, Medical Device & Equipment Manufacturers, Testing Laboratories, Research & Development, and Medical Laboratories & Diagnostic Imaging Centers.<sup>20</sup> Each of these segments include between one and ten industries at the six-digit NAICS definition. Table C-1 in Appendix C provides a detailed list of the industries included in each segment of the bioscience sector.<sup>21</sup>

### BIOSCIENCE EMPLOYMENT TRENDS

There were 12,739 employees in the bioscience sector in Northeast Ohio in 2007, a gain of 230 employees, or 1.8%, since 2000. NEO's bioscience employment grew at a slower rate over the 7-year period than in Ohio (6.4%) and in the United States (5.8%) (Figure 5). Between 2000 and 2004, the bioscience sector grew in Northeast Ohio as well as in Ohio and the United States. However, during the following years, between 2004 and 2007, Northeast Ohio lost bioscience employment at the same time that the state and nation experienced employment gains.

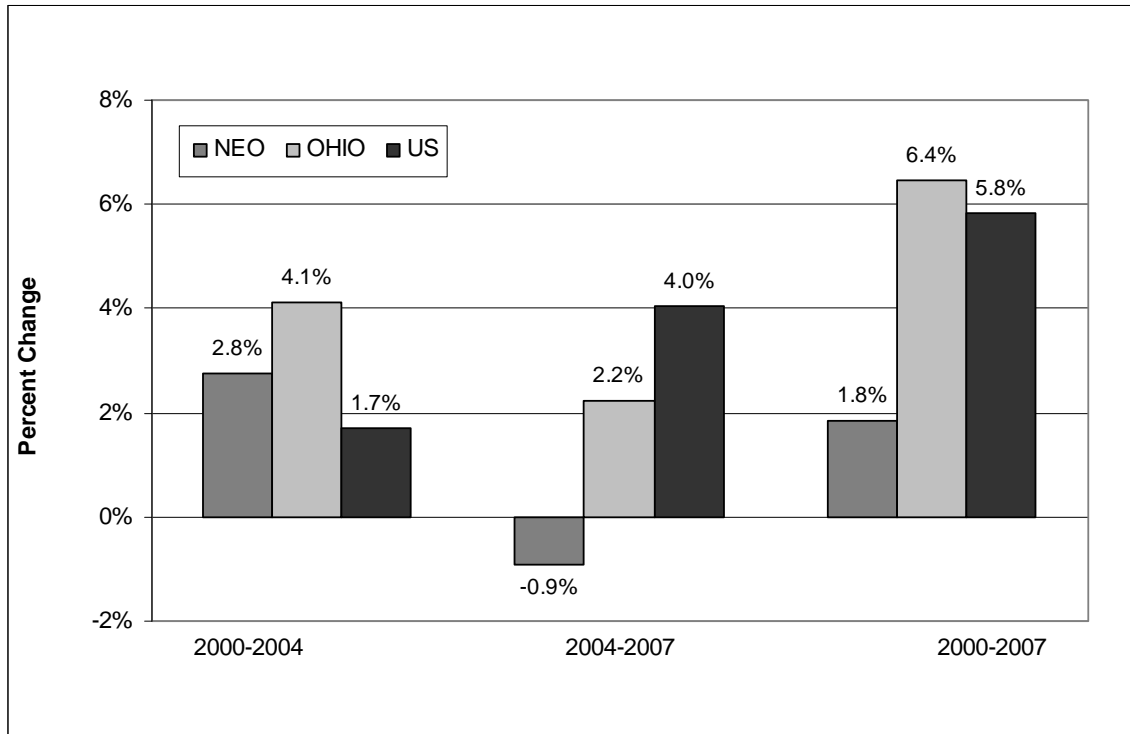
Between 2000 and 2007, the bioscience sector performed better than all industries in Northeast Ohio and statewide. Bioscience employment in Northeast Ohio grew by 1.8% in comparison to an employment loss of 5.7% in all industries. In Ohio, bioscience employment rose by 6.4% in comparison to a decline of 3.7% economy wide. The United States experienced gains in bioscience of (5.8%) and overall economy (4.8%).

---

<sup>20</sup> The segments of Testing Laboratories and Research & Development include companies that are not bio-related. To capture only the bioscience portion of these segments, this report uses the same ratios that were used in the *Ohio Bioscience Growth Report*. The Ohio Bioscience report includes one additional segment, *Miscellaneous*, which includes information about ten specific companies throughout Ohio. We excluded this sub-category because only two of these companies are located in Northeast Ohio and confidentiality restrictions preclude us from reporting data for less than three companies.

<sup>21</sup> Some of the six-digit bioscience industries are included in the high-tech industries analyzed earlier, while others are not. As a result, employment and other data on the bioscience sector cannot be added to the other high-tech industries because of potential duplications.

**Figure 5. Employment Change in Bioscience: NEO, Ohio, and the U.S., 2000-2007**



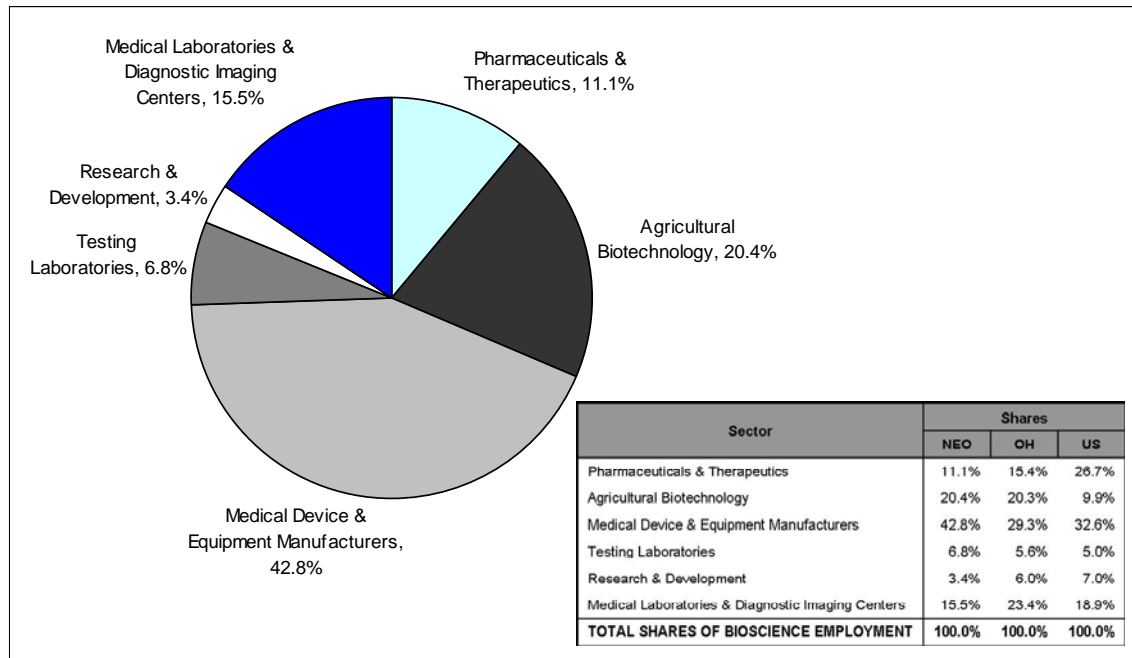
Although bioscience is a growing sector, it started from a small base, and it has a very small share of the total economy. By 2007, the share of the bioscience sector in the United States was higher than that share in Northeast Ohio and the state of Ohio. In 2007, the bioscience sector accounted for only 0.64% of total employment in Northeast Ohio in comparison to 0.82% of total employment in the United States (Table 9). The sector's share of the overall economy increased between 2000 and 2007 in Northeast Ohio (from 0.59% to 0.64%), while it remained stable in the United States (0.82%).

**Table 9. Bioscience Shares of Total Employment and Payroll**

Year	Employment (%)			Payroll (%)		
	NEO	OH	US	NEO	OHIO	U.S.
2000	0.59	0.56	0.82	1.02	0.82	1.36
2004	0.64	0.61	0.83	1.19	0.91	1.46
2007	0.64	0.62	0.82	1.22	0.90	1.46

The largest segments of the bioscience sector in Northeast Ohio in 2007 were Medical Device & Equipment Manufacturers (5,453 jobs or 42.8% of bioscience), Agricultural Biotechnology (2,597 jobs or 20.4%) and Medical Laboratories & Diagnostic Imaging Centers (1,974 jobs or 15.5%) (Figure 6). The Medical Device & Equipment Manufacturers segment, NEO's largest, suffered job losses of almost 700 employees, or 11.1%, between 2000 and 2007 (Tables C-2 in Appendix C). This segment is also the largest segment in the United States; it too suffered an employment decline of 1.7% over the 7-year period.

**Figure 6. Total NEO Bioscience Employment by Segment, 2007**



Employment in Agricultural Biotechnology, the second largest segment in Northeast Ohio, grew only in 2001 and 2002. Overall, there was a 16.5% decrease in employment in the segment between 2000 and 2007 in Northeast Ohio. In Ohio and the United States, this segment also lost employment at a rate of 10.4% and 16.2%, respectively.

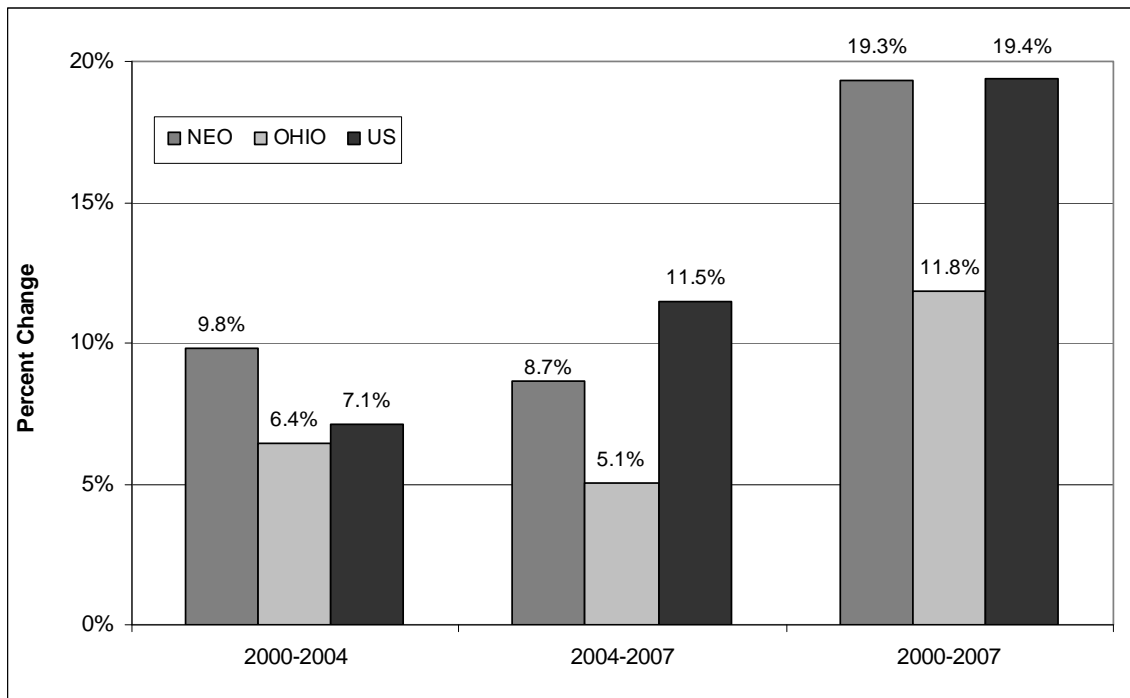
Bioscience-related Research & Development was NEO's smallest segment in terms of employment. By 2007, it became the second smallest industry in Ohio following bioscience-related Testing Laboratories (Table 10). The bioscience-related Research & Development segment saw gains in all three geographies between 2000 and 2007. In Northeast Ohio it represents only 3.4% of total bioscience employment and it grew by 78.2% between 2000 and 2007.

The Medical Device & Equipment Manufacturers is the largest bioscience segment in Northeast Ohio, Ohio, and nationally. However, it plays a larger role in NEO's bioscience sector; this segment accounts for 42.8% of all bioscience employment in the region in comparison to 29.3% in Ohio and 32.6% in the United States. The dominance of Medical Device & Equipment Manufacturers in Northeast Ohio suggests that policy makers need to pay special attention to this industry and continue to promote and grow it.

## BIOSCIENCE PAYROLL TRENDS

Following growth in employment, payroll in NEO's bioscience sector also grew between 2000 and 2007 after adjusting for inflation. Bioscience payroll also grew in all three regions during both time periods (2000-2004 and 2004-2007) (Figure 7). Between 2000 and 2007, bioscience payroll grew by 19.3% in Northeast Ohio, a higher rate of growth than in Ohio (11.8%) and nearly the same rate as the United States (19.5%). Moreover, the gains seen in bioscience payroll were in comparison to a near stagnation in overall payroll in NEO's economy. Between 2000 and 2004, bioscience payroll grew in Northeast Ohio by 9.8% in comparison to a 5.7% decline in total payroll. Between 2004 and 2007, total payroll in the overall economy grew (5.6%), but at a lower rate than bioscience payroll (8.7%). Overall, between 2000 and 2007, bioscience payroll increased by 19.3% compared to a slight decline in NEO's total payroll (-0.4%).

**Figure 7. Payroll Change in Bioscience Segments: NEO, Ohio, and the U.S., 2000-2007**



Although payroll in the bioscience sector grew at a fast rate, the sector is still very small; it is relatively smaller in Northeast Ohio and Ohio than nationally. By 2007, the share of bioscience payroll in Northeast Ohio (1.22%) was lower than the national economy (1.46%), but higher than this sector in Ohio (0.90%). The share of bioscience payroll in Northeast Ohio, Ohio, and the United States rose between 2000 and 2007 (Table 9 above).

## BIOSCIENCE AVERAGE WAGE TRENDS

Average wage in NEO's bioscience sector was \$77,524 in 2007. This was 91.9% higher than the average wage of \$40,399 in all industries in Northeast Ohio (Table 10). This gap between the two was the largest in Northeast Ohio in comparison to the United States (77.8%) and Ohio (44.5%). NEO's average wage in the bioscience sector was significantly higher than in Ohio (\$59,533), but slightly lower than the average wage in the national bioscience sector (\$81,343).

Analyzing bioscience by segment shows that in Northeast Ohio, Agricultural Biotechnology paid the highest average wage in 2007 (\$123,583) followed by Medical Laboratories & Diagnostic Imaging Centers (\$108,036). They were the two highest paying bioscience segments throughout the 2000 to 2007 years. These ranks are different than the national order, where the segments with the highest average wage were Pharmaceutical & Therapeutics and Research & Development.

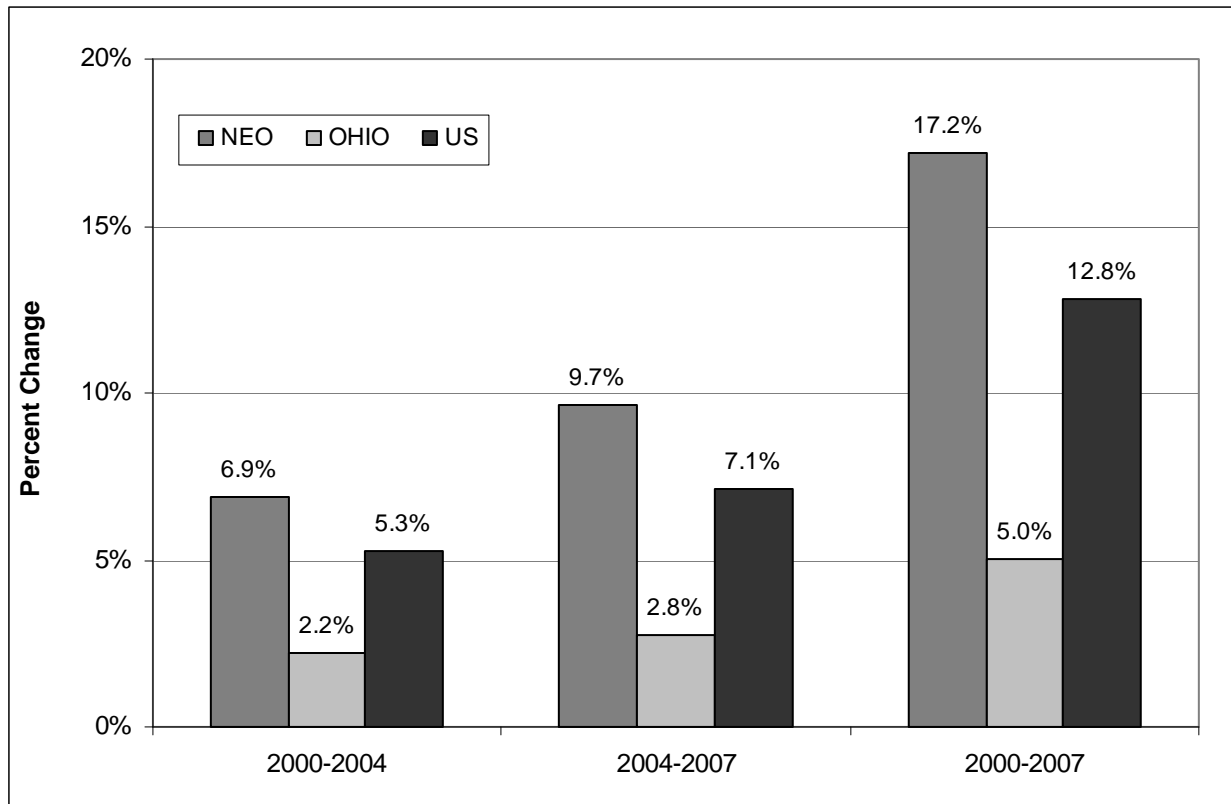
**Table 10. Average Wage in Bioscience, 2007**

Segment	Average Wages		
	NEO	OH	US
Pharmaceuticals & Therapeutics	\$79,501	\$70,972	\$120,548
Agricultural Biotechnology	123,583	90,063	72,547
Medical Device & Equipment Manufacturers	48,187	46,899	78,614
Testing Laboratories	47,656	37,808	55,167
Research & Development	84,553	78,070	102,128
Medical Laboratories & Diagnostic Imaging Centers	108,036	41,881	50,817
NEO BIOSCIENCES AVERAGE WAGE	77,524	59,553	80,569
NEO AVERAGE WAGE	40,399	41,224	45,964

NEO's average wages in the bioscience sector increased by 17.2% between 2000 and 2007 reflecting gains in both time periods (2000-2004 and 2004-2007) (Figure 8). NEO's average wages grew a great deal faster than bioscience wages in Ohio (5.0%) and the United States. (12.9%). While average wage in NEO's bioscience grew faster than nationally, NEO's average wage for all industries grew at a slower rate than in the United States.

In Northeast Ohio, average wages in four of the six bioscience segments increased between 2000 and 2007; the exceptions were Testing Laboratories and Medical Laboratories & Diagnostic Imaging Centers. Ohio's average wage increased in all segments except for Medical Device & Equipment Manufacturers while in the United States, average wages increased in all segments.

**Figure 8. Average Wage Change in Bioscience Segments: NEO, Ohio, and the U.S., 2000-2007**



## TRENDS IN BIOSCIENCE ESTABLISHMENTS

By 2007, there were 533 establishments in NEO's bioscience sector, which reflected a loss of 90 establishments, or 14.5%, since 2000. The total number of establishments declined between 2000 and 2004 and then increased between 2004 and 2007. Over the whole period (2000-2007), the number of establishments in Northeast Ohio declined by 14.5% in comparison to gains of 24.9% in Ohio and 15.7% in the United States.

The average employment size of a NEO bioscience establishment in 2007 was 23.9 employees, compared to 25.0 employees in Ohio and 27.4 in the United States. However, the average size of a bioscience establishment was larger than the average size of an establishment in all sectors combined in all three geographies.

## RESEARCH & DEVELOPMENT

Research and development (R&D) activity in Northeast Ohio is primarily assessed in terms of industry R&D funding and academic R&D expenditures. Both industry and academic R&D are examined from 2000 to 2006. Academic R&D expenditures are examined in terms of funding source and by academic institution. This section also provides some information on the R&D activity of two of the region's major non-academic research institutions: The Cleveland Clinic and NASA Glenn Research Center.

### INDUSTRY RESEARCH & DEVELOPMENT

Over the longer term (2000-2006), industry R&D funding in Northeast Ohio increased 9% in contrast to declines elsewhere in the state (-18%), in the Midwest (-6%), and in the United States (-5%).<sup>22</sup> Between 2006 and 2007, NEO experienced remarkable growth of R&D funding of 30% compared to a 9% growth in the rest of Ohio and 6% growth of industry R&D in the United States. (Table 11 and Figure B-6 in Appendix B).

**Table 11. Estimated Industry R&D Funding by Sub-Region, 2000-2006**  
(in Millions of 2006 Dollars)

MSA/county	2000	2001	2002	2003	2004	2005	2006	2000-06 (%)	2005-06 (%)
Akron	196.7	189.8	147.1	138.6	118.1	202.8	494.5	151	144
Canton Massillon	169.4	168.8	154.0	94.2	41.0	25.7	21.4	-87	-17
Cleveland-Elyria-Mentor	837.4	956.2	925.2	889.3	807.3	862.7	967.6	16	12
Mansfield	87.0	92.0	78.7	70.5	66.6	57.4	63.8	-27	11
Sandusky	18.3	17.6	6.8	13.8	10.9	7.9	8.1	-56	3
Youngstown-Warren	25.5	22.9	19.5	17.2	10.5	7.1	6.9	-73	-4
Non-Metro Counties	278.9	247.2	231.7	201.7	180.3	194.9	200.1	-28	3
Northeast Ohio	1,613.3	1,694.4	1,574.1	1,425.5	1,226.7	1,358.5	1,762.5	9	30
Reminder of Ohio	6,179.2	6,197.3	5,639.5	5,544.6	4,577.9	4,651.5	5,089.5	-18	9
Ohio Total	7,850.5	7,969.8	7,216.4	6,953.3	5,825.8	6,039.3	6,852.0	-13	13
Midwest	51,474.8	46,728.1	43,870.6	45,544.7	43,611.4	47,130.3	48,268.0	-6	2
U.S.	259,362.9	245,322.3	228,143.8	225,822.2	222,315.8	233,454.8	247,669.0	-5	6

The Akron metro area experienced the largest percentage increase between 2000 and 2006 (144%), more than doubling R&D funding between 2005 and 2006. The Cleveland-Elyria-Mentor MSA experienced a 16% growth in funding over the longer period with 12% growth for the last year alone. This MSA still secures the vast majority of NEO's industrial R&D funding (about 55% in 2006) and, together with Akron, captures 83% of the regional R&D funding.

<sup>22</sup> Industry R&D funding at the regional level is estimated from state-level data. See methodology section for further detail. Funding is reported in 2007 dollars, adjusting for inflation.

However, when industry R&D funding is calculated per employee, Northeast Ohio significantly lags the state, the Midwest, and the United States (Table 12). This is partially explained by the higher density of population in Northeast Ohio compared to any of the benchmarked geographies. In 2006, industry R&D funding per employee in Northeast Ohio was just over half the amount for the remainder of the state, approximately 42% of the R&D for the Midwest, and 47% for the nation. Over the longer term, industry R&D funding in Northeast Ohio grew faster than the rest of the state and the Midwest; it narrowed the gap slightly but the difference remains considerable.

To achieve the level of industry R&D funding per employee in the remainder of Ohio, Northeast Ohio should have added \$1,406 million between 2005 and 2006 in addition to the \$404 million increase already achieved. To reach the R&D funding per employee in the United States, Northeast Ohio should have added an additional \$1,952 million. Finally, to achieve R&D funding per employee in the Midwest, Northeast Ohio should have added \$2,386 million or a total of seven times more than the region added in 2006.

**Table 12. Estimated Industry R&D Funding per Employee, 2000-2006**  
(2006 Dollars)

	2000	2001	2002	2003	2004	2005	2006
Northeast Ohio	761	807	772	712	610	674	881
Remainder of Ohio	1,934	1,939	1,598	1,748	1,438	1,448	1,585
Ohio Total	1,690	1,598	1,349	1,344	1,121	1,155	1,315
Midwest	2,092	2,095	1,860	1,988	1,891	2,026	2,074
U.S.	2,858	2,151	1,815	1,782	1,725	1,775	1,858

## ACADEMIC RESEARCH & DEVELOPMENT

NEO's colleges and universities reported \$432.1 million in research expenditures in FY 2006.<sup>23</sup> Case Western Reserve University is the dominant educational research institution in the region, accounting for 86% of NEO's academic R&D expenditures. Northeast Ohio accounted for only 26% of the academic R&D expenditures in Ohio, since other large research universities are located in other regions of the state, namely The Ohio State University in Columbus and The University of Cincinnati. NEO's share represents a slight improvement in academic R&D compared to 2005 when its share was 25%. A large amount of research activity in Northeast Ohio takes place outside academic institutions, such as the Cleveland Clinic Lerner Research Institute and NASA Glenn Research Center.

The federal government supported 78% of the research that was undertaken by the region's academic institutions in 2006, a significant increase from the 63% share reported in 2005. It is the primary source of R&D funding at all NEO academic institutions with the exception of The University of Akron and Cleveland State University, which have a smaller share of federal funding (Table 13).

<sup>23</sup> The Ohio Agricultural Research and Development Center (OARDC), located in Wooster, Ohio (Wayne County) is part of The Ohio State University and therefore its research activities are not captured in data on Northeast Ohio institutions. In FY06, OARDC attracted \$38.7 million in grants, contracts, and gifts. (Source: OARDC website, <http://oardcreport.osu.edu/>).

Academic R&D expenditures in Northeast Ohio increased 39% between 2000 and 2006 (Table 14 and Figure B-7). Colleges and universities across Ohio reported a 37% increase in research expenditures over the same time period. Case Western Reserve University reported a large increase (48.3%), driving the overall increase for the region. Three of Northeast Ohio's largest research institutions—Case Western Reserve University, The University of Akron, and Cleveland State University—all reported increases while John Carroll University, Kent State University, and Oberlin College experienced a decline (Table B-4 in Appendix B).

**Table 13. R&D Expenditures at NEO Colleges and Universities  
by Funding Source, FY 2006**  
(in Thousands of 2006 Dollars)

Institution	Total	Federal Government		State and Local Government	Industry	Institutional Funds	All other sources
		Total	Share (%)				
U.S.	47,760,402	30,033,156	62.9	3,016,240	2,427,627	9,062,058	3,221,321
Midwest	7,401,004	4,372,224	59.1	445,026	379,458	1,714,528	489,768
Ohio	1,636,473	1,005,905	61.5	150,297	136,151	264,701	79,419
Northeast Ohio Institutions	432,128	337,098	78.0	21,081	10,855	36,536	26,558
U. Akron	28,440	11,433	40.2	724	3,316	9,413	3,554
Case Western Reserve U.	369,264	306,980	83.1	16,148	6,277	19,050	20,809
Cleveland State U.	14,496	5,159	35.6	3,205	231	4,599	1,302
John Carroll U.	474	452	95.4	0	22	0	0
Kent State U. (all campuses)	11,076	8,198	74.0	735	700	1,443	0
NEO Univ. C. of Medicine	5,294	2,754	52.0	133	114	1,859	434
Oberlin C.	810	548	67.7	0	128	134	0
C. Wooster	966	507	52.5	0i	0i	0i	459
Youngstown State U.	1,308	1,067	81.6%	136	67	38	0

i=data point imputed by NSF

Source: National Science Foundation/Division of Science Resource Statistics, Survey of Research and Development Expenditures at Universities and Colleges, FY 2006. [http://www.nsf.gov/statistics/nsf08300/content.cfm?pub\\_id=3797&id=2](http://www.nsf.gov/statistics/nsf08300/content.cfm?pub_id=3797&id=2)

**Table 14. R&D Expenditures at Northeast Ohio Colleges and Universities, FY 2000-2006**  
(in Thousands of 2006 Dollars)

Institution	2000	2001	2002	2003	2004	2005	2006	2000-06 (%)	2005-06 (%)
U.S.	39,924,715	37,753,111	39,912,881	42,320,807	44,220,077	47,226,296	47,760,402	19.6	1.1
Midwest	6,089,494	6,361,374	6,887,875	7,341,394	7,383,558	7,242,240	7,401,004	21.5	2.2
Ohio	1,193,757	1,225,975	1,337,632	1,457,056	1,439,655	1,567,069	1,636,473	37.1	4.4
Northeast Ohio Institutions	310,244	306,331	336,690	361,900	323,626	393,869	432,128	39.3	9.7
U. Akron	25,150	27,139	33,615	32,179	29,906	27,390	28,440	13.1	3.8
Case Western Reserve U.	249,061	241,640	262,217	288,568	252,190	329,656	369,264	48.3	12.0
Cleveland State U.	13,177	15,828	16,586	16,245	18,374	16,180	14,496	10.0	-10.4
John Carroll U.	1,383e	628	985	509	520	515	474	-65.7	-8.0
Kent State U.	13,955	13,792	15,404	16,748	13,830	11,251	11,076	-20.6	-1.6
NEO Univ. C. of Medicine	5,175	5,524	5,417	5,024	6,094	5,809	5,294	2.3	-8.9
Oberlin C.	891	396	526	542	415	1,079	810	-9.1	-24.9
C. Wooster	765	349	433	475	306e	581	966	26.3	66.4
Youngstown State U.	686	1,035	1,507	1,609	1,992	1,408	1,308	90.6	-7.1

e = estimated by NSF

Source: National Science Foundation/Division of Science Resources Statistics, Survey of Research and Development Expenditures at Universities and Colleges, FY 2000-2006

Although Northeast Ohio has experienced solid growth in academic R&D overall, due to the density of its population and employment Northeast Ohio again lags the state, the Midwest, and the nation in its level of funding when R&D expenditures are calculated per employee (Table 15). In 2006, per employee expenditures in Northeast Ohio were about two-thirds the Ohio and the Midwest totals, and just over 60% of the national figure. Northeast Ohio may have an advantage over many other areas in terms of research conducted at institutions not captured in this data (see below); however, the lack of comparable data prevents further analysis.

**Table 15. Academic R&D Expenditures per Employee, 2000-2006**  
(in 2006 Dollars)

Institution	2000	2001	2002	2003	2004	2005	2006
Northeast Ohio Institutions	146	146	165	181	161	195	216
Remainder of Ohio	277	288	284	345	351	365	375
Ohio	257	246	250	282	277	300	314
Midwest	248	285	292	320	320	311	318
U.S.	440	331	318	334	343	359	358

## INSTITUTIONAL RESEARCH

Industry funding and academic research expenditures capture only a portion of the research activity being conducted in Northeast Ohio. Directly comparable data on R&D expenditures is not available for the Cleveland Clinic and NASA Glenn Research Center; however, both institutions conduct a significant amount of research.

The Cleveland Clinic's Lerner Research Institute is formally affiliated with Case Western Reserve University and constitutes a significant scientific base for regional biomedical research. Being among the top 10 recipients in the country, the Cleveland Clinic Lerner Research Institute was awarded about \$85 million by NIH in 2006. The total research funding grew from \$137 million in 2002 to \$180 million in 2004, \$223 million in 2006, and \$239 million in 2007. The amount of donations increased from \$1.6 million in 2002 to \$2.16 million in 2004, \$3.45 million in 2006, and more than \$11.1 million in 2007.<sup>24</sup>

Scientists and engineers at the NASA Glenn Research Center investigate space operations, aerospace technology, and technologies needed for space exploration. In FY 2007, Glenn Research Center reported annual research expenditures of \$635.2 million.<sup>25</sup> It is important to note that NASA contracts with local universities to conduct research and includes these contract dollars in its reported research expenditures. Therefore, some of the same dollars are captured in NASA and university research expenditures.

---

<sup>24</sup> According to Lerner Research Institute Scientific Report, 2008-2009. <http://www.lerner.ccf.org/news/sr/documents/sr2008-09.pdf>. Downloaded January, 2009.

<sup>25</sup> Source: NASA Glenn Research Center, Office of the Chief Financial Officer, January 2009.

## **CONCLUDING REMARKS AND POLICY IMPLICATIONS**

This report provides an ongoing monitoring tool describing changes in the high-tech sector in Northeast Ohio. Tracking a specific set of measures on an annual basis provides policy makers with a method for assessing progress and directing resources.

High-tech employment in the United States and Northeast Ohio followed similar trends. The period of growth ending in 2001 was followed by a sharp decline and slow recovery over the following few years. While the high-tech declines in Northeast Ohio and the United States were similar, Northeast Ohio began its recovery a year earlier (2004, but grew at a slower rate. Beyond the high-tech sector, the performance of the overall economies differed. Following a two-year decline, the U.S. economy grew at a fast pace after 2004, while NEO's total employment followed a downward trend since 2000.

Although Northeast Ohio significantly lags the nation and the Midwest in the rate of growth in the high-tech sector, employment in Northeast Ohio's high-tech industries has risen 2.7% since 2004, despite an overall decline of 0.2% in the region's employment across all industries. In absolute terms, Northeast Ohio added 4,436 jobs in the high-tech sector between 2004 and 2007 and lost 3,162 jobs overall in that same period.

NEO's high-tech sector accounts for a larger share of gross regional product than its share of employment and is more productive than other sectors of the regional economy. High-tech industries have a high average wage relative to other industries; average wages in NEO's high-tech sector far exceed average wages across all industries, which was also the case in the Midwest and the nation.

Estimates of industry R&D indicate that Northeast Ohio has seen increased investment over the last 10 years despite declines statewide. Moreover, between 2005 and 2006, Northeast Ohio showed remarkable growth of industry R&D funding compared to the rest of Ohio and the United States. Academic R&D has also been steadily increasing in the region, although Ohio's largest research institutions are located elsewhere in the state. The level of R&D funding in Northeast Ohio is still much lower than the rest of Ohio, the Midwest and United States when viewed in relation to employment levels (reflecting the relative size of the economies).

Several issues revealed in this report deserve attention by civic leaders and policy makers. The positive dynamic of the latest year's growth in industry and academic R&D should be reinforced and supported. Strongly associated with economic growth, regional R&D capacity strengthens the base for growing productivity and GRP in the region. The significant increase of industry R&D in the Akron MSA and academic R&D at Case Western Reserve University and the Cleveland Clinic might create a base for reinforcement of R&D activity in Northeast Ohio.

Although regional average wages in high-tech industries were growing during 2006-2007, they were still significantly lower in Northeast Ohio as compared to the nation; the rate of growth was insignificant and small compared to the large gap they needed to bridge. Lower average wages might reflect an intra-industry mix of companies that are involved in less sophisticated activities compared to other regions in the country.

Two large NEO technology groups, Advanced Manufacturing and Advanced Materials, displayed positive dynamics in their economic performance. Steady growth of Advanced Manufacturing, seen with a double-digit increase in GRP and productivity over 2004 to 2007, illustrates an example of a successful cluster composed of viable companies. A modest employment decline in the Advanced Materials group, paired with double-digit growth in productivity and wages during 2004 to 2007, identifies this cluster's strong economic position. Public policy directed to this technology group should consider growing competition in these industries from other Midwest states.

Three other small but fast-growing technology groups—Energy and Power & Propulsion, Science and Engineering, and Electronics—deserve close attention from policy leaders. Together with the growing bioscience sector, these industries are building the core of a new regional economic structure in Northeast Ohio.

## APPENDIX A: NORTECH SERVICE AREA

### Metropolitan Areas

- Akron MSA
  - Portage County
  - Summit County
- Canton-Massillon MSA
  - Carroll County
  - Stark County
- Cleveland-Elyria-Mentor MSA
  - Cuyahoga County
  - Geauga County
  - Lake County
  - Lorain County
  - Medina County
- Mansfield MSA
  - Richland County
- Sandusky MSA
  - Erie County
- Youngstown-Warren-Boardman MSA
  - Mahoning County
  - Trumbull County
  - Mercer County, PA\*

### Non-Metro Counties

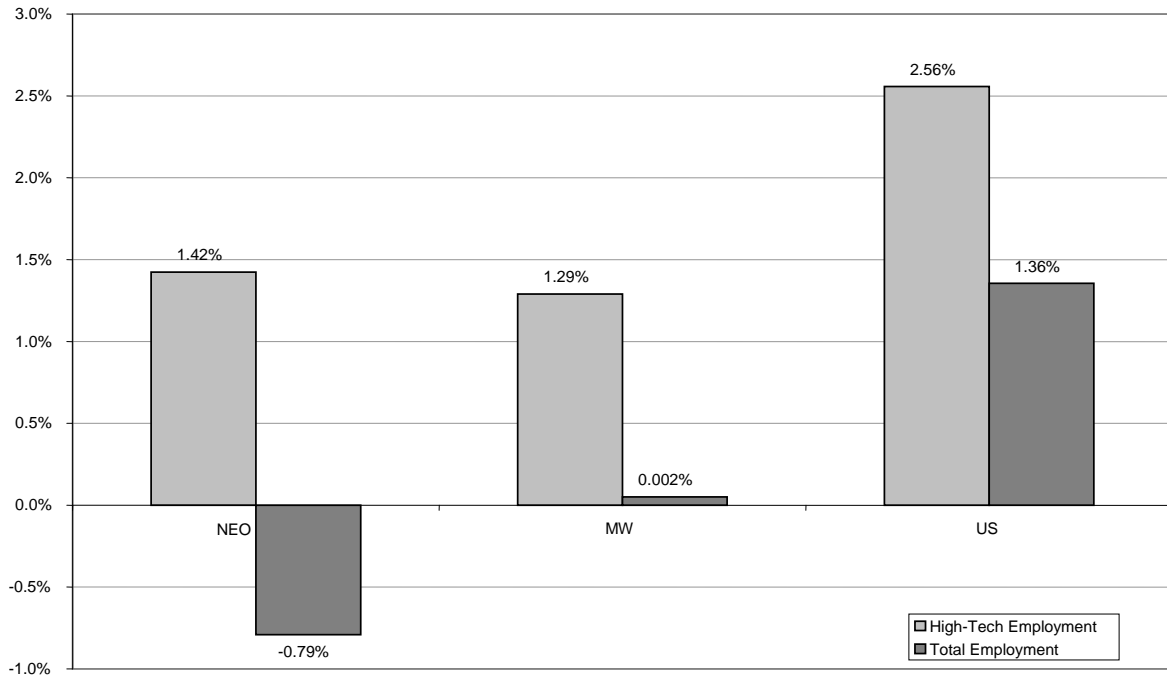
- Ashland County
- Ashtabula County
- Columbiana County
- Crawford County
- Holmes County
- Huron County
- Tuscarawas County
- Wayne County

\* Mercer County is not included in the analyses, with the exception of the section on employment in high-tech occupations.

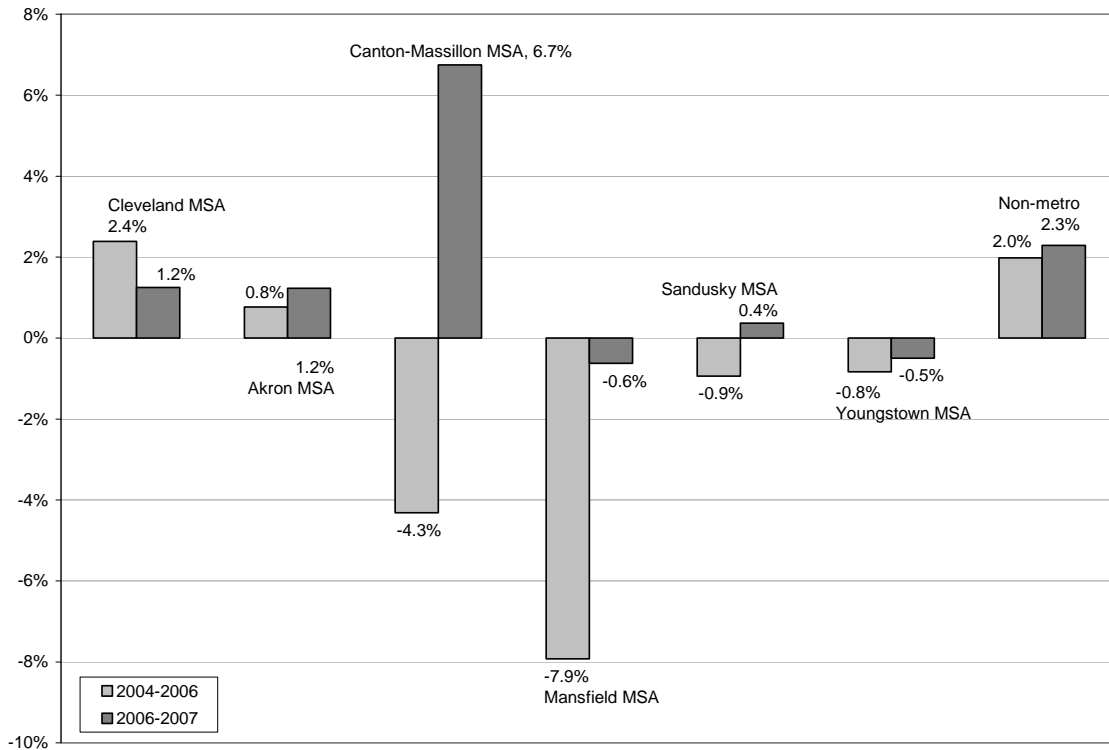
## **APPENDIX B: DETAILED TABLES AND FIGURES FOR THE HIGH-TECH SECTOR**

- Table B-1. Employment Change by Technology Group: NEO, the Midwest and U.S. 2004-2007, Percentage Change
- Table B-2. GRP Change by Technology Group: NEO, the Midwest and U.S., 2004-2007.
- Table B-3. Share of Total GRP by Technology Group, NEO, the Midwest and U.S., 2004-2007
- Table B-4. Change of R&D Expenditures at NEO Colleges and Universities by Funding Source, 2005-2006
- 
- Figure B-1. Employment Change: NEO, the Midwest, and U.S., 2006-2007
- Figure B-2. Total High-Tech Employment by MSA: Percentage Change, 2004-2006, 2006-2007
- Figure B-3. NEO High-Tech Employment Change by Technology Group: 2004-2006, 2006-2007
- Figure B-4. Employment Change by Technology Group: NEO, the Midwest, and U.S., 2004-2007
- Figure B-5. Productivity Change by Technology Group, NEO, the Midwest and U.S., 2006-2007
- Figure B-6. Change in Estimated Industry R&D Funding
- Figure B-7. Change in Academic R&D Expenditures, 2000-2006

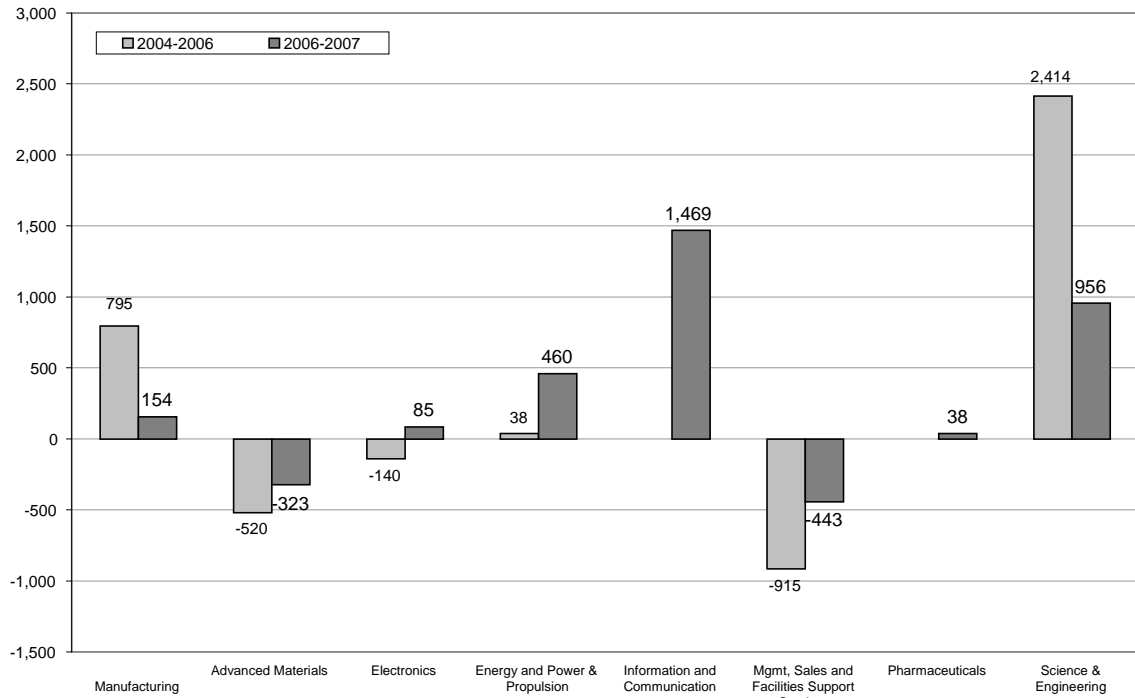
**Figure B-1. Employment Change: NEO, the Midwest, and U.S., 2006-2007**



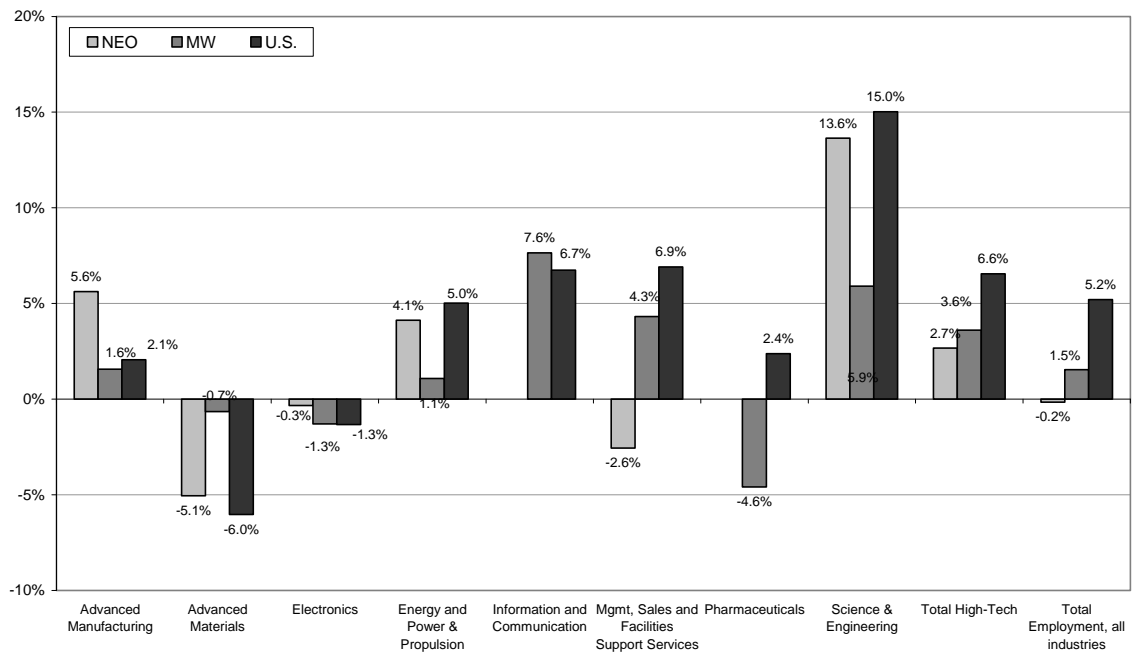
**Figure B-2. Total High-Tech Employment by MSA: Percentage Change, 2004-2006, 2006-2007**



**Figure B-3. NEO High-Tech Employment Change by Technology Group: 2004-2006, 2006-2007**



**Figure B-4. Employment Change by Technology Group: NEO, the Midwest, and U.S., 2004-2007**



**Table B-1. Employment Change by Technology Group: NEO, the Midwest and U.S. 2004-2007, Percentage Change**

NAICS	Technology Group	2007 Emp	2004-2006 % Emp Change			2006-2007 % Emp Change			2004-2007 % Emp Change		
		NEO	NEO	MW	U.S.	NEO	MW	U.S.	NEO	MW	U.S.
<b>Total Advanced Manufacturing</b>		<b>17,816</b>	<b>4.7%</b>	<b>1.9%</b>	<b>1.2%</b>	<b>0.9%</b>	<b>-0.3%</b>	<b>0.9%</b>	<b>5.6%</b>	<b>1.6%</b>	<b>2.1%</b>
3332	Industrial machinery manufacturing	3,853	13.8%	8.3%	1.5%	-0.7%	1.9%	2.7%	13.0%	10.3%	4.3%
3333	Commercial and service industry machinery mfg	1,786	-11.9%	-7.7%	-5.2%	0.1%	-2.0%	-1.7%	-11.8%	-9.6%	-6.8%
3339	Other general-purpose machinery mfg	12,065	5.1%	2.5%	3.0%	2.0%	-0.3%	1.4%	7.2%	2.1%	4.5%
3369	Other transportation equipment mfg	113	-5.2%	0.0%	6.4%	-31.0%	-3.4%	-1.5%	-34.6%	-3.4%	4.8%
<b>Total Advanced Materials</b>		<b>15,841</b>	<b>-1.9%</b>	<b>-2.3%</b>	<b>-4.5%</b>	<b>-3.4%</b>	<b>1.7%</b>	<b>-1.6%</b>	<b>-5.2%</b>	<b>-0.7%</b>	<b>-6.0%</b>
3251	Basic chemical manufacturing	4,376	-5.8%	-3.8%	-6.8%	-1.5%	0.5%	0.7%	-7.2%	-3.3%	-6.1%
3252	Resin, synthetic rubber, & artificial synthetic fibers & filaments mfg	3,351	9.2%	17.2%	-3.4%	-0.3%	5.6%	0.8%	8.9%	23.8%	-2.6%
3253	Pesticide, fertilizer, and other agricultural chemical mfg	306	-19.3%	-19.6%	-8.2%	-44.2%	16.4%	-5.5%	-55.0%	-6.4%	-13.2%
3255	Paint, coating, and adhesive manufacturing	4,650	-0.2%	-5.3%	-2.8%	-4.3%	-2.9%	-4.2%	-4.5%	-8.1%	-6.9%
3259	Other chemical product and preparation mfg	3,158	-1.7%	-5.3%	-2.0%	0.5%	0.3%	-4.1%	-1.2%	-5.0%	-6.0%
<b>Total Pharmaceuticals</b>		<b>1,419</b>	<b>N/A</b>	<b>-2.8%</b>	<b>0.7%</b>	<b>N/A</b>	<b>-1.8%</b>	<b>1.7%</b>	<b>N/A</b>	<b>-4.6%</b>	<b>2.4%</b>
3254	Pharmaceutical and medicine manufacturing	1,419	N/A	-2.8%	0.7%	N/A	-1.8%	1.7%	N/A	-4.6%	2.4%
<b>Total Electronics</b>		<b>16,435</b>	<b>-0.9%</b>	<b>-0.7%</b>	<b>-0.1%</b>	<b>0.5%</b>	<b>-0.6%</b>	<b>-1.2%</b>	<b>-0.3%</b>	<b>-1.3%</b>	<b>-1.3%</b>
3341	Computer and peripheral equipment mfg	602	0.1%	-1.0%	-7.0%	2.4%	-5.8%	-5.3%	2.5%	-6.7%	-11.9%
3342	Communications equipment manufacturing	1,010	-6.9%	-5.5%	-1.6%	-18.1%	-7.5%	-10.2%	-23.8%	-12.6%	-11.6%
3344	Semiconductor and other electronic component mfg	2,843	13.0%	2.8%	1.2%	0.6%	0.3%	-0.3%	13.6%	3.1%	0.9%
3345	Navigational, measuring, electromedical, and control instruments mfg	5,789	-7.9%	-0.5%	1.6%	4.8%	3.4%	1.5%	-3.5%	3.0%	3.1%
3353	Electrical equipment manufacturing	5,134	5.0%	-2.7%	-0.1%	1.5%	-0.6%	1.3%	6.6%	-3.2%	1.2%
8112	Electronic and precision equipment repair and maintenance	1,058	-11.0%	0.8%	3.7%	-5.9%	-6.4%	-0.1%	-16.2%	-5.6%	3.5%
<b>Total Energy and Power &amp; Propulsion</b>		<b>12,552</b>	<b>0.3%</b>	<b>1.4%</b>	<b>2.6%</b>	<b>3.8%</b>	<b>-0.3%</b>	<b>2.4%</b>	<b>4.1%</b>	<b>1.1%</b>	<b>5.0%</b>
2111	Oil and gas extraction	461	-4.2%	-5.8%	7.9%	21.9%	7.5%	9.1%	16.7%	1.3%	17.7%
2211	Electric power generation, transmission, and distribution	5,323	-6.4%	-0.9%	-3.3%	4.5%	-0.4%	0.1%	-2.2%	-1.3%	-3.2%
3241	Petroleum and coal products manufacturing	1,310	3.0%	0.4%	-0.1%	1.1%	-1.4%	2.5%	4.1%	-1.1%	2.3%
3336	Engine, turbine, and power transmission equipment mfg	1,451	8.1%	4.1%	8.8%	0.9%	-3.0%	0.2%	9.1%	1.0%	9.1%
3364	Aerospace product and parts mfg	3,753	7.5%	5.3%	7.6%	2.4%	3.7%	3.2%	10.1%	9.2%	11.1%
4861	Pipeline transportation of crude oil	N/A	N/A	9.5%	-4.4%	N/A	6.6%	11.9%	N/A	16.7%	7.0%
4862	Pipeline transportation of natural gas	161	0.4%	2.0%	-0.8%	-1.4%	-0.1%	-1.2%	-1.0%	1.9%	-2.0%
4869	Other pipeline transportation	N/A	N/A	10.5%	7.1%	N/A	-1.7%	9.1%	N/A	8.6%	16.8%
<b>Total Information and Communication Technology</b>		<b>26,844</b>	<b>N/A</b>	<b>0.8%</b>	<b>1.4%</b>	<b>N/A</b>	<b>6.8%</b>	<b>5.2%</b>	<b>N/A</b>	<b>7.6%</b>	<b>6.7%</b>
3343	Audio and video equipment mfg	N/A	N/A	-15.0%	-4.2%	N/A	-5.3%	-4.5%	N/A	-19.5%	-8.6%
3346	Manufacturing and reproducing, magnetic and optical media	156	2.2%	-3.1%	-11.2%	-0.6%	-14.0%	-5.1%	1.5%	-16.7%	-15.8%
5112	Software publishers	655	-3.4%	3.6%	2.1%	-1.5%	1.5%	3.8%	-4.9%	5.1%	5.9%
5161	Internet publishing and broadcasting	0	-60.5%	19.3%	14.2%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%
5171	Wired telecommunications carriers	8,416	-3.7%	-14.9%	-12.6%	10.2%	37.9%	36.0%	6.1%	17.3%	18.9%
5172	Wireless telecommunications carriers (except satellite)	1,397	3.8%	4.7%	4.5%	1.5%	7.1%	4.3%	5.3%	12.1%	9.0%
5173	Telecommunications resellers	0	-99.4%	-5.9%	-16.2%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%
5174	Satellite telecommunications	13	-42.2%	19.0%	2.5%	-18.8%	-14.2%	-18.2%	-53.0%	2.1%	-16.2%
5179	Other telecommunications	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
5181	Internet service providers and web search portals	0	-29.1%	-8.4%	0.7%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%	-100.0%
5182	Data processing, hosting, and related services	2,068	-6.4%	-4.1%	-1.3%	4.9%	1.9%	2.8%	-1.9%	-2.3%	1.5%
5415	Computer systems design and related services	12,740	14.6%	9.9%	11.4%	5.9%	7.2%	6.9%	21.4%	17.8%	19.0%
<b>Total Management, Sales and Facilities Support Services</b>		<b>51,624</b>	<b>-1.7%</b>	<b>3.6%</b>	<b>4.1%</b>	<b>-0.9%</b>	<b>0.7%</b>	<b>2.7%</b>	<b>-2.6%</b>	<b>4.3%</b>	<b>6.9%</b>
1131	Forestry	N/A	N/A	129.5%	-2.9%	N/A	-28.2%	-5.2%	N/A	64.7%	-8.0%
4234	Professional and commercial equipment and supplies, merchant wholesalers	9,212	-3.3%	1.8%	1.0%	0.0%	-0.6%	1.5%	-3.3%	1.2%	2.5%
5211	Monetary authorities, central bank	N/A	N/A	-36.0%	-4.8%	N/A	-99.7%	1.8%	N/A	-99.8%	-3.1%
5232	Securities and commodity exchanges	N/A	N/A	3.1%	0.7%	N/A	-0.3%	-0.8%	N/A	2.8%	-0.1%
5511	Management of companies and enterprises	39,724	-2.4%	3.7%	5.1%	-1.1%	1.2%	2.9%	-3.5%	4.9%	8.1%
5612	Facilities support services	1,733	18.3%	25.4%	8.8%	-1.2%	1.0%	7.5%	16.8%	26.6%	17.0%
<b>Total Science &amp; Engineering</b>		<b>28,071</b>	<b>9.8%</b>	<b>6.2%</b>	<b>11.8%</b>	<b>3.5%</b>	<b>-0.3%</b>	<b>2.9%</b>	<b>13.6%</b>	<b>5.9%</b>	<b>15.0%</b>
5413	Architectural, engineering, and related services	15,522	3.1%	3.5%	9.3%	2.4%	1.6%	4.2%	5.6%	5.1%	13.9%
5416	Management, scientific, and technical consulting services	9,327	15.0%	12.7%	18.4%	5.9%	-1.1%	2.9%	21.9%	11.5%	21.7%
5417	Scientific research-and-development services	3,222	34.5%	3.7%	8.6%	2.1%	-3.8%	0.1%	37.3%	-0.3%	8.7%
<b>Total High-Tech</b>		<b>170,602</b>	<b>1.2%</b>	<b>2.3%</b>	<b>3.9%</b>	<b>1.4%</b>	<b>1.3%</b>	<b>2.6%</b>	<b>2.7%</b>	<b>3.6%</b>	<b>6.6%</b>
<b>Total Employment, all industries</b>		<b>1,999,668</b>	<b>0.6%</b>	<b>1.5%</b>	<b>3.8%</b>	<b>-0.8%</b>	<b>0.0%</b>	<b>1.4%</b>	<b>-0.2%</b>	<b>1.5%</b>	<b>5.2%</b>

Note: Industries with suppressed data are included in the totals.

**Table B-2. GRP Change by Technology Group: NEO, the Midwest and U.S., 2004-2007**

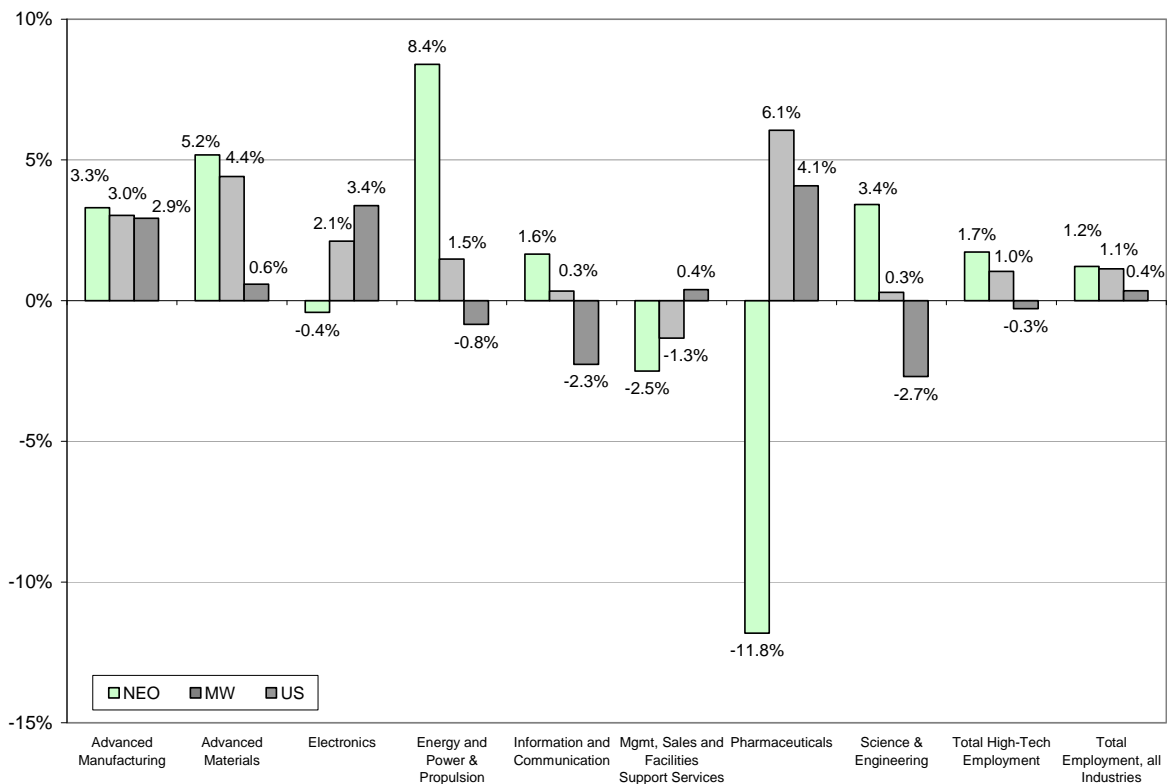
NAICS	Technology Group	2007 GRP			2004-2006 % GRP Change			2006-2007 % GRP Change			2004-2007 % GRP Change		
		NEO	NEO	MW	U.S.	NEO	MW	U.S.	NEO	MW	U.S.		
<b>Total Advanced Manufacturing</b>		<b>1,561</b>	<b>10.8%</b>	<b>6.5%</b>	<b>4.0%</b>	<b>4.1%</b>	<b>1.7%</b>	<b>4.7%</b>	<b>15.4%</b>	<b>8.3%</b>	<b>8.9%</b>		
3332	Industrial machinery manufacturing	342	10.4%	15.4%	5.6%	7.5%	2.7%	4.0%	18.7%	18.5%	9.9%		
3333	Commercial and service industry machinery mfg	132	-17.8%	-0.5%	-1.7%	5.3%	-1.1%	3.3%	-13.4%	-1.6%	1.6%		
3339	Other general-purpose machinery manufacturing	985	18.5%	11.2%	8.1%	1.5%	1.6%	5.2%	20.3%	13.0%	13.8%		
3369	Other transportation equipment manufacturing	102	-8.7%	-24.4%	-10.8%	19.7%	4.8%	7.2%	9.3%	-20.7%	-4.5%		
<b>Total Advanced Materials</b>		<b>2,884</b>	<b>5.3%</b>	<b>-1.6%</b>	<b>-0.5%</b>	<b>2.0%</b>	<b>4.2%</b>	<b>0.1%</b>	<b>7.4%</b>	<b>2.5%</b>	<b>-0.4%</b>		
3251	Basic chemical manufacturing	922	5.2%	-1.8%	-1.6%	0.8%	3.8%	-1.0%	6.0%	1.9%	-2.6%		
3252	Resin, synthetic rubber, and artificial synthetic fibers and filaments mfg	529	1.8%	13.3%	1.2%	8.1%	6.4%	0.3%	10.0%	20.5%	1.5%		
3253	Pesticide, fertilizer, and other agricultural chemical manufacturing	192	15.0%	-8.2%	-7.1%	7.1%	2.7%	0.6%	23.2%	-5.8%	-6.6%		
3255	Paint, coating, and adhesive manufacturing	723	4.1%	-6.7%	1.6%	-5.1%	-1.0%	1.6%	-1.2%	-7.6%	3.2%		
3259	Other chemical product and preparation manufacturing	519	7.6%	-4.8%	1.1%	7.5%	8.1%	1.2%	15.7%	2.9%	2.3%		
<b>Total Pharmaceuticals</b>		<b>418</b>	<b>30.9%</b>	<b>0.8%</b>	<b>9.2%</b>	<b>-3.8%</b>	<b>4.0%</b>	<b>5.9%</b>	<b>25.8%</b>	<b>4.8%</b>	<b>15.7%</b>		
3254	Pharmaceutical and medicine manufacturing	418	30.9%	0.8%	9.2%	-3.8%	4.0%	5.9%	25.8%	4.8%	15.7%		
<b>Total Electronics</b>		<b>1,758</b>	<b>14.1%</b>	<b>7.9%</b>	<b>4.7%</b>	<b>3.1%</b>	<b>1.4%</b>	<b>2.9%</b>	<b>17.6%</b>	<b>9.4%</b>	<b>7.8%</b>		
3341	Computer and peripheral equipment manufacturing	63	11.0%	8.7%	3.7%	2.2%	-1.8%	4.9%	13.4%	6.8%	8.8%		
3342	Communications equipment manufacturing	68	37.6%	6.9%	-0.4%	-19.0%	-6.6%	-1.1%	11.5%	-0.1%	-1.5%		
3344	Semiconductor and other electronic component manufacturing	132	10.7%	17.2%	6.6%	5.7%	-0.5%	3.9%	17.0%	16.6%	10.8%		
3345	Navigational, measuring, electromedical, and control instruments mfg	418	17.2%	9.1%	3.0%	7.3%	6.7%	1.8%	25.7%	16.4%	4.9%		
3353	Electrical equipment manufacturing	988	15.6%	3.8%	10.8%	3.4%	2.1%	5.2%	19.5%	5.9%	16.5%		
8112	Electronic and precision equipment repair and maintenance	88	-15.1%	-0.9%	3.7%	-1.0%	-3.8%	-0.7%	-15.9%	-4.7%	2.9%		
<b>Total Energy and Power &amp; Propulsion</b>		<b>4,736</b>	<b>15.5%</b>	<b>9.3%</b>	<b>15.7%</b>	<b>6.8%</b>	<b>2.2%</b>	<b>2.0%</b>	<b>23.3%</b>	<b>11.7%</b>	<b>18.0%</b>		
2111	Oil and gas extraction	499	36.7%	41.5%	38.5%	7.0%	10.3%	3.9%	46.2%	56.0%	43.8%		
2211	Electric power generation, transmission, and distribution	3,040	12.2%	6.7%	3.5%	10.3%	1.9%	-1.4%	23.8%	8.7%	2.1%		
3241	Petroleum and coal products manufacturing	458	15.6%	18.6%	20.7%	-7.7%	4.2%	5.2%	6.7%	23.6%	27.0%		
3336	Engine, turbine, and power transmission equipment mfg	113	25.7%	11.6%	12.5%	-4.4%	1.1%	5.3%	20.2%	12.8%	18.4%		
3364	Aerospace product and parts manufacturing	552	14.2%	4.8%	5.9%	4.7%	1.1%	3.5%	19.5%	6.0%	9.6%		
4860	Pipeline transportation	73.5	24.0%	1.2%	-5.0%	2.1%	-9.5%	2.0%	26.7%	-8.4%	-3.1%		
<b>Total Information and Communication Technology</b>		<b>3,839</b>	<b>3.2%</b>	<b>2.1%</b>	<b>4.3%</b>	<b>5.9%</b>	<b>1.4%</b>	<b>0.2%</b>	<b>9.3%</b>	<b>3.5%</b>	<b>4.5%</b>		
3343	Audio and video equipment manufacturing	2	-10.1%	-1.8%	-0.9%	-2.6%	-4.1%	-3.5%	-12.4%	-5.8%	-4.3%		
3346	Manufacturing and reproducing, magnetic and optical media	6	-37.0%	-6.3%	-15.7%	0.4%	-2.1%	-5.2%	-36.7%	-8.3%	-20.1%		
5112	Software publishers	146	-16.8%	10.4%	15.6%	-5.4%	-3.0%	0.9%	-21.3%	7.1%	16.6%		
5161	Internet publishing and broadcasting	188	1.8%	26.9%	28.7%	-8.4%	-12.8%	1.7%	-6.8%	10.7%	30.9%		
5171	Wired telecommunications carriers	1,123	-11.3%	-13.0%	-9.2%	11.5%	4.2%	-2.5%	-1.1%	-9.3%	-11.5%		
5172	Wireless telecommunications carriers (except satellite)	174	8.7%	13.5%	6.7%	-26.2%	-21.6%	-2.4%	-19.8%	-11.0%	4.1%		
5173	Telecommunications resellers	112	-16.2%	2.0%	-12.8%	-16.1%	-23.1%	-2.2%	-29.6%	-21.5%	-14.7%		
5174	Satellite telecommunications	2	-53.9%	11.3%	7.0%	-38.1%	-16.2%	5.9%	-71.5%	-6.8%	13.3%		
5179	Other telecommunications	207	-20.3%	15.9%	-4.9%	1322.1%	2559.2%	1.7%	1033.5%	2982.0%	-3.3%		
5181	Internet service providers and web search portals	26	-12.3%	-0.6%	16.6%	-55.6%	-34.9%	4.5%	-61.1%	-35.3%	21.8%		
5182	Data processing, hosting, and related services	76	-4.8%	4.2%	12.6%	-13.4%	-6.7%	-2.9%	-17.6%	-2.8%	9.3%		
5415	Computer systems design and related services	1,777	21.3%	8.5%	11.1%	3.5%	1.8%	2.8%	25.6%	10.5%	14.3%		
<b>Total Management, Sales and Facilities Support Services</b>		<b>6,615</b>	<b>3.2%</b>	<b>-5.6%</b>	<b>-1.4%</b>	<b>-1.7%</b>	<b>-1.9%</b>	<b>1.1%</b>	<b>1.5%</b>	<b>-7.4%</b>	<b>-0.3%</b>		
11**	Farming, Forestry and Hunting (Not including Logging)	478.4	-24.1%	-32.5%	-18.8%	-18.9%	-16.8%	-0.9%	-38.4%	-43.8%	-19.6%		
4234	Professional & commercial equipment & supplies, merchant wholesalers	1,506	6.0%	5.1%	3.5%	-2.3%	-2.2%	2.3%	3.6%	2.9%	5.9%		
5211	Monetary authorities, central bank	92	7.4%	2.7%	5.1%	8.2%	10.4%	7.4%	16.3%	13.4%	12.8%		
5232	Securities and commodity exchanges	2	-17.0%	7.3%	7.3%	429.8%	10.5%	14.0%	339.6%	18.6%	22.3%		
r5111	Management of companies and enterprises	4,433	7.1%	0.5%	6.4%	0.5%	1.3%	1.2%	7.6%	1.7%	7.6%		
5612	Facilities support services	105	11.6%	25.9%	11.3%	2.5%	36.3%	3.2%	14.4%	71.6%	14.8%		
<b>Total Science &amp; Engineering</b>		<b>3,200</b>	<b>16.7%</b>	<b>8.1%</b>	<b>13.1%</b>	<b>2.3%</b>	<b>0.5%</b>	<b>2.1%</b>	<b>19.3%</b>	<b>8.6%</b>	<b>15.5%</b>		
5413	Architectural, engineering, and related services	1,511	4.8%	5.4%	11.3%	3.0%	1.6%	1.8%	7.9%	7.0%	13.3%		
5416	Management, scientific, and technical consulting services	1,193	22.0%	12.7%	17.0%	2.3%	-1.5%	3.9%	24.8%	11.0%	21.5%		
5417	Scientific research-and-development services	496	52.1%	7.3%	11.4%	0.0%	1.1%	0.5%	52.1%	8.4%	12.0%		
<b>Total High-Tech GRP</b>		<b>25,011</b>	<b>9.9%</b>	<b>4.6%</b>	<b>8.5%</b>	<b>3.1%</b>	<b>1.6%</b>	<b>1.7%</b>	<b>13.3%</b>	<b>6.3%</b>	<b>10.4%</b>		
<b>Total GRP, all industries</b>		<b>172,329</b>	<b>3.7%</b>	<b>2.9%</b>	<b>6.0%</b>	<b>1.2%</b>	<b>1.3%</b>	<b>1.6%</b>	<b>4.9%</b>	<b>4.2%</b>	<b>7.8%</b>		

Note: Data for industries NAICS 4861, 4862, 4869 were unavailable and they are included in NAICS 4860.

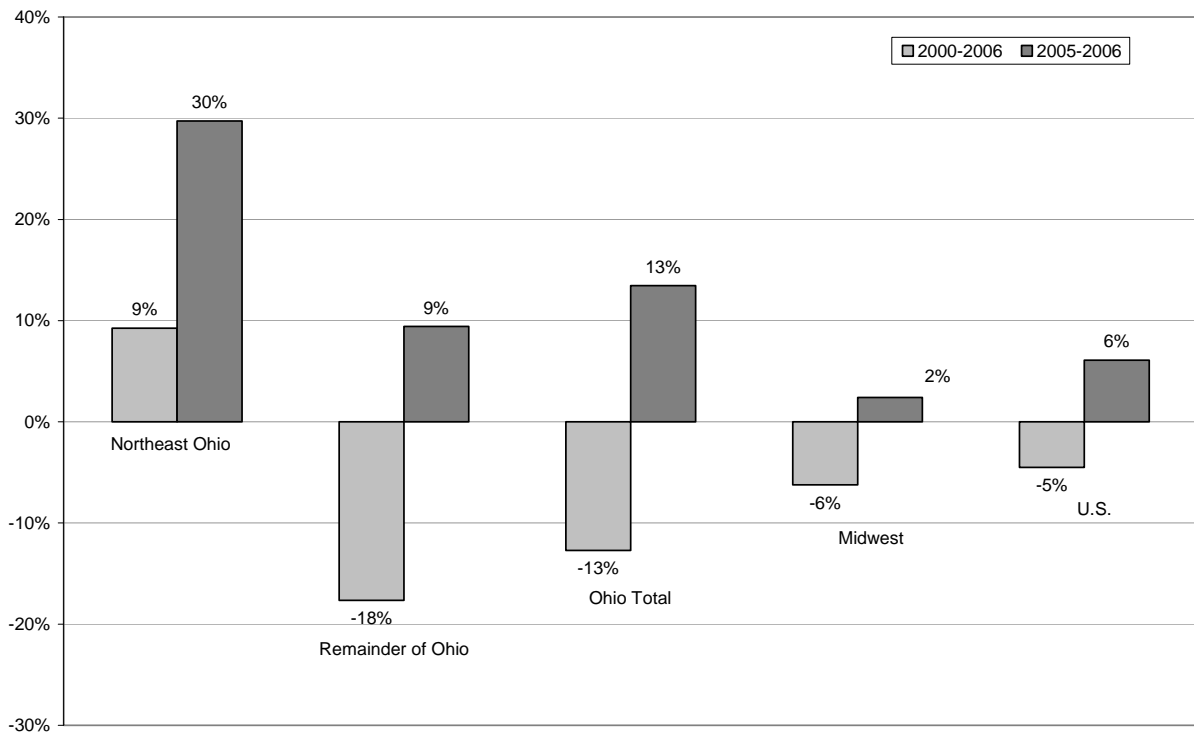
**Table B-3. Share of Total GRP by Technology Group, NEO, the Midwest and U.S., 2004-2007**

Technology Group	2004 (%)			2006 (%)			2007 (%)		
	NEO	MW	U.S.	NEO	MW	U.S.	NEO	MW	U.S.
Advanced Manufacturing	0.8	0.8	0.9	0.9	0.8	0.8	0.8	0.8	0.4
Advanced Materials	1.6	1.6	1.7	1.7	0.9	0.9	0.9	0.9	0.9
Electronics	0.9	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.3
Energy and Power & Propulsion	2.3	2.5	2.6	2.7	2.5	2.6	2.6	2.7	3.7
Information and Communication	N/A	2.1	2.1	2.2	3.0	3.1	3.0	3.0	4.3
Mgmt, Sales & Facilities Support	4.0	3.9	4.0	3.8	4.4	4.1	4.0	3.9	4.0
Pharmaceuticals	N/A	0.2	0.3	0.2	0.9	0.9	0.9	0.9	0.7
Science & Engineering	1.6	1.7	1.8	1.9	2.5	2.6	2.7	2.6	2.8
Total High-Tech Industries	13.6	13.9	14.3	14.5	16.0	15.9	15.9	15.8	18.0
Total All Industries	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

**Figure B-5. Productivity Change by Technology Group, NEO, the Midwest and U.S., 2006-2007**



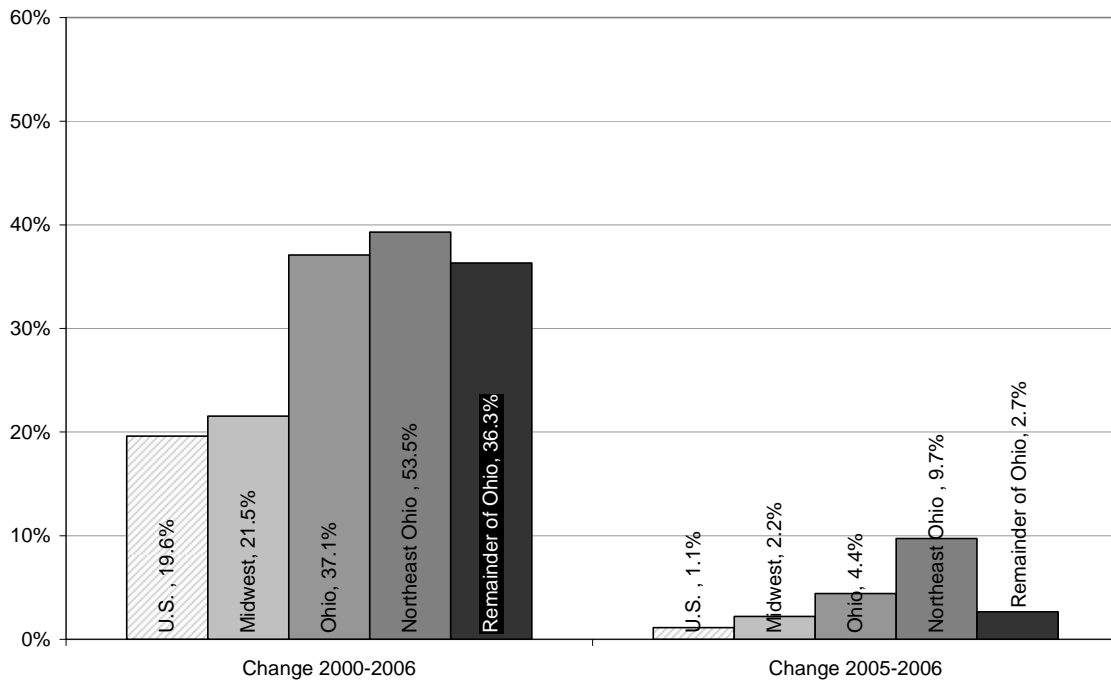
**Figure B-6. Change in Estimated Industry R&D Funding**



**Table B-4. Change of R&D Expenditures at NEO Colleges and Universities by Funding Source, 2005-2006**

Institution	Total (%)	Federal Government (%)	State and Local Government (%)	Industry (%)	Institutional Funds (%)	All other sources (%)
U.S.	1.1	-0.2	-0.6	2.6	6.3	0.9
Midwest	2.2	1.4	-6.7	3.2	8.9	-4.2
Ohio	4.4	10.2	-12.4	3.8	11.5	-30.7
Northeast Ohio Institutions	9.7	35.8	-27.0	-55.0	102.4	-64.4
U. Akron	3.8	9.5	29.0	-4.5	1.3	-1.9
Case Western Reserve U.	12.0	41.8	-30.9	-67.0	1486.2	-70.1
Cleveland State U.	-10.4	-29.7	-15.1	-28.7	18.7	49.8
John Carroll U.	-8.0	28.6	-100.0	-73.0	0.0	0.0
Kent State U. (all campuses)	-1.6	5.6	-6.9	-21.8	-20.1	0.0
NEO Univ. C. of Medicine	-8.9	-17.2	-42.5	33.2	5.9	6.0
Oberlin C.	-24.9	-36.0	0.0	-18.4	105.5	0.0
C. Wooster	66.4	6.6	0.0	0.0	0.0	337.5
Youngstown State U.	-7.1	-8.	42.0	-30.0	-33.4	0.0

Figure B-7. Change in Academic R&D Expenditures, 2000-2006



## APPENDIX C: BIOSCIENCE SECTOR INDUSTRY DESCRIPTION AND DETAILED ANALYSIS

**Table C-1. Bioscience Sector Industries**

NAICS Code	Bioscience Sector
<b>Pharmaceuticals &amp; Therapeutics</b>	
325411	Medicinal and Botanical Manufacturing
325412	Pharmaceutical Preparation Manufacturing
325413	In-Vitro Diagnostic Substance Manufacturing
325414	Biological Product (except Diagnostic) Manufacturing
<b>Agricultural Biotechnology</b>	
311221	Wet Corn Milling
311222	Soybean Processing
311223	Other Oilseed Processing
325193	Ethyl Alcohol Manufacturing
325199	All Other Basic Organic Chemical Manufacturing
325221	Cellulosic Organic Fiber Manufacturing
325311	Nitrogenous Fertilizer Manufacturing
325312	Phosphatic Fertilizer Manufacturing
325314	Fertilizer (Mixing Only) Manufacturing
325320	Pesticide and Other Agricultural Chemical Manufacturing
<b>Medical Device and Equipment</b>	
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing
334516	Analytical Laboratory Instrument Manufacturing
334517	Irradiation Apparatus Manufacturing
339111	Medical Equipment and Supplies Manufacturing
339112	Surgical and Medical Instrument Manufacturing
339113	Surgical Appliance and Supplies Manufacturing
339114	Dental Equipment and Supplies Manufacturing
339115	Ophthalmic Goods Manufacturing
<b>Testing Labs</b>	
339116	Dental Laboratories
541380	Testing Laboratories*
<b>Research and Development</b>	
541710	Research and Development in the Physical, Engineering, and Life Sciences*
<b>Medical Lab &amp; Diagnostic Imaging Centers</b>	
621511	Medical Laboratories
621512	Diagnostic Imaging Centers

\* Only a portion of these industries is counted as Bioscience.

Source: Ohio Bioscience Growth Report, December 2007, published by BioOhio.

**Table C-2. Employment Change in Bioscience Segments: NEO, Ohio, and the U.S., 2000-2007**

Segment	Employment	Percentage Change in Employment								
	2007	2000-2004			2004-2007			2000-2007		
	Total NEO	NEO	OHIO	US	NEO	OHIO	US	NEO	OHIO	US
Pharmaceuticals & Therapeutics	1,419	35.5	17.1	6.2	30.1	8.5	2.4	76.3	27.0	8.7
Agricultural Biotechnology	2,597	-0.7	-2.8	-13.6	-15.9	-7.9	-3.0	-16.5	-10.4	-16.2
Medical Device & Equipment Manufacturers	5,453	-5.5	-12.8	-4.5	-6.0	-1.6	3.0	-11.1	-14.2	-1.7
Testing Laboratories*	861	-2.6	-0.7	6.6	0.7	-1.0	0.8	-1.9	-1.7	7.5
Research & Development*	434	28.5	17.1	6.7	38.6	10.9	9.3	78.2	29.9	16.6
Medical Laboratories & Diagnostic Imaging Centers	1,974	28.0	40.9	17.2	15.5	12.8	11.8	47.9	58.9	31.1
<b>OVERALL BIOSCIENCE EMPLOYMENT</b>	<b>12,739</b>	<b>2.8</b>	<b>4.1</b>	<b>1.7</b>	<b>-0.9</b>	<b>2.2</b>	<b>4.0</b>	<b>1.8</b>	<b>6.4</b>	<b>5.8</b>
<b>OVERALL EMPLOYMENT</b>	<b>1,999,668</b>	<b>-5.5</b>	<b>-4.4</b>	<b>-0.4</b>	<b>-0.2</b>	<b>0.7</b>	<b>5.2</b>	<b>-5.7</b>	<b>-3.7</b>	<b>4.8</b>

\*Only portions of these industries are counted as Bioscience.