High-Technology Employment Growth in Major U.S. Metropolitan Areas

Zoltan J. Acs
Adrien Ndikumwami

ABSTRACT. High technology employment has received little attention in shift-share analysis. The purpose of this paper is to utilize shift-share analysis to analyze high technology employment change in 37 metropolitan areas. We find that shift share analysis is a useful tool to study employment gains and losses in metropolitan areas. Most of the gains and losses in a metropolitan area can be explained by the regions competitiveness component.

1. Introduction

As we close the final chapter of the 20th century, it has become clear that many cities, communities, and even whole regions have declined in the U.S. as industry after industry has succumbed to fierce international competition and rapid technological obsolescence. However, the same forces that swept away the past are transforming the landscape as new high technology clusters are emerging all over America.

Shift-share analysis has become a very popular tool for analyzing regional employment change. While earlier papers have focused on one version of the shift-share technique, this paper looks at shift-share analysis from both absolute and relative perspectives. The purpose of this paper is to utilize the traditional approach of shift-share to analyze high technology employment change in 37 metropolitan areas. A new variable, labor force, is introduced to permit inter-metropolitan comparison by converting absolute numbers into relative numbers. High technology in metropolitan areas has received little attention in shift-share analysis. Barkley (1988) explains the shift of high technology manufacturing from metropolitan areas to non-metropolitan areas. However, little has been done in analyzing high technology at the industry level and at the metropolitan area level.

This paper has two objectives: (1) to utilize the traditional shift-share technique in both absolute and relative terms and illustrate why both are necessary, and (2) to give the first account of the recent trend of high technology industries in U.S. metropolitan areas. In Section 2 we introduce the data, followed by a description of the technique in Section 3. Section 4 provides a regional analysis and Section 5 concludes by providing an industry by industry analysis of high technology employment. We find that shift share analysis is a useful tool to study employment shifts in metropolitan areas. Most of the gains and losses in a MSA an be explained by the regions competitiveness component.

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Zoltan J. Acs
U.S. Small Business Administration
Merrick School of Business
University of Baltimore
Baltimore, MD 21201-5779

and

Adrien Ndikumwami
RESI
Towson University
Towson, MD 21252-7097

2. Data

The Bureau of Labor Statistics (BLS) supplied employment, ES-202 series data, for the years 1988 and 1991. Employment data are reported to the BLS by State Employment Security Agencies (SESAs) and cover 98% of civilian employees. While an initial year prior to 1988 may be desirable for terms of increasing the length of the period of analysis, we chose 1988 to avoid complications caused by the reclassification of SIC codes in 1987. Labor force data are also supplied by the BLS and reflect data gathered as part of the Local Area Unemployment Statistics (LAUS) program.

Thirty-two 3-digit SIC industries were chosen

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and grouped in 6 high technology industries as identified by Acs (1996). These industries are: Biotechnology and Biomedical, Defense and Aerospace, Information Technology, Energy and Chemicals, High Technology Machinery and Instruments, and High Technology Research (Appendix A).

A sample of 37 metropolitan statistical areas (MSAs) was selected using the criteria of high technology development, venture capital, innovation, and university R&D. For instance, urban centers like San Jose, Boston, and San Francisco have large venture capital communities while New York, Baltimore, and Los Angeles have a high concentration of university research. Finally, the MSAs were grouped into three main categories depending on the size of the average labor force between 1988 and 1991. The first category, small-size MSAs (SSM), has 11 MSAs with an average labor force of less than 0.6 million. The second category, medium-size MSAs (MSM), has 13 MSAs with an average labor force between 0.6 million and 1.2 million. The last category, large-size MSAs (LSM), has 13 MSAs with an average labor force greater than 1.2 million. The MSA grouping is detailed in Appendix B. The 37 MSAs represent 52.9% of U.S. high technology employment. On an industry basis, the sample ranges from 30.51% for energy and chemicals to 77.63% for information technology and services.

Table I ranks clusters by high technology importance and growth. Between 1988 and 1991, 17 of the MSAs in the sample have more than 1% of the U.S. high technology employment. Los Angeles leads the sample with 6.17% of U.S high technology employment. The cities with the highest employment growth rates are Austin (36.8), Charlotte (21.85), San Francisco (21.6), and Raleigh/Durham (17.8).

3. Shift-share technique

Ever since Creamer (1942) set the tone of shift-share analysis and Perloff et al. (1960) revived it by using it in regional economic analysis, the model has been a subject of controversies. The debate has centered around the model's effectiveness as a predictive and analytical tool. Praskevopoulos (1971), Ashby (1964), James and Hughes (1973), Andrikopoulos et al. (1990), Ireland and Moomaw (1981) – just to name a few – have written in support of the model, while Houston (1967) and Brown (1969) have questioned the validity of the model. By the same token, Kalbacher (1979), Klaasen et al. (1972), and McDonough and Sihag (1991) have proposed different versions of shift-share either by including multiple bases or by including relative weights for variables used in computations.

In this study a traditional shift-share analysis is used to describe employment growth in each of the 37 metropolitan statistical areas under study by taking into account employment in all MSAs combined. The change in high technology employment in industry i in MSA j can be broken up into three components: (1) the national growth component, (2) the industry mix component, and (3) the competitive or regional share component.

We define the national growth component as the high technology employment change of metropolitan area j and industry i assuming i is growing at the national growth rate. The growth rate of all metropolitan areas combined will be used for national growth. We also define the actual growth as the difference between high technology employment in 1988 and 1991 for industry i and MSA j. The net relative growth is equal to the difference between the national growth and the actual growth. The sum of net relative growth for all the 6 industries make up for total net relative growth of a metropolitan area. Net relative growth is calculated as follows:

$$\mathrm{NRG}_j = \sum (r_{ij} - s)\ \mathrm{HTEMP}_{ij} \quad \text{for } j = 1, \ldots, 6 \quad j = 1, \ldots, 37 \tag{1}$$

where

NRG_j = Net Relative Growth of high technology employment for the metropolitan statistical area (MSA) j between 1988 and 1991,

HTEMP_{ij} = 1988 employment for high technology industry i and metropolitan area (MSA) j,

r_{ij} = Employment growth rate for high technology industry i and MSA j between 1988 and 1991,

s = employment growth rate for all high technology industries and all MSAs between 1988 and 1991.

TABLE I
U.S. High technology employment*

Metropolitan area	High tech employment in 1988	Rank	High tech employment in 1991	Rank	Percentage. of U.S. high tech (1991)	Rank	Employment growth rate (1988–1991)	Rank
Austin	33,696	(28)	46,118	(23)	0.76%	(23)	36.86%	(1)
Charlotte	1,263	(37)	1,539	(37)	0.03%	(37)	21.85%	(2)
San Francisco	36,288	(26)	44,127	(25)	0.73%	(25)	21.60%	(3)
Raleigh	46,228	(22)	54,472	(20)	0.90%	(20)	17.83%	(4)
Houston	124,939	(9)	145,289	(9)	2.39%	(9)	16.29%	(5)
Seattle	135,751	(8)	157,607	(6)	2.60%	(6)	16.10%	(6)
Miami	18,664	(36)	21,427	(32)	0.35%	(32)	14.80%	(7)
Portland	38,002	(25)	41,887	(26)	0.69%	(26)	10.22%	(8)
Atlanta	60,346	(18)	65,617	(16)	1.08%	(16)	8.73%	(9)
Salt Lake City	32,052	(30)	34,711	(28)	0.57%	(28)	8.30%	(10)
Washington	141,291	(7)	150,045	(7)	2.47%	(7)	6.20%	(11)
San Diego	96,909	(12)	100,232	(12)	1.65%	(12)	3.43%	(12)
Richmond	18,866	(35)	19,399	(33)	0.32%	(33)	2.83%	(13)
Indianapolis	50,024	(21)	50,795	(22)	0.84%	(22)	1.54%	(14)
Cincinnati	52,883	(20)	53,303	(21)	0.88%	(21)	0.79%	(15)
Denver	56,585	(19)	56,955	(18)	0.94%	(18)	0.65%	(16)
Cleveland	60,958	(17)	61,173	(17)	1.01%	(17)	0.35%	(17)
Dallas	150,134	(6)	149,249	(8)	2.46%	(8)	–0.59%	(18)
Phoenix	83,273	(15)	82,176	(14)	1.35%	(14)	–1.32%	(19)
Columbus	34,403	(27)	33,544	(29)	0.55%	(29)	–2.50%	(20)
Philadelphia	167,770	(5)	162,587	(5)	2.68%	(5)	–3.09%	(21)
Pittsburg	45,687	(23)	44,206	(24)	0.73%	(24)	–3.24%	(22)
Chicago	204,009	(4)	192,830	(4)	3.18%	(4)	–5.48%	(23)
San Jose	255,600	(3)	239,256	(2)	3.94%	(2)	–6.39%	(24)
Minneapolis	121,955	(10)	113,378	(10)	1.87	(10)	–7.03	(25)
Louisville	28,914	(31)	26,781	(31)	0.44%	(31)	–7.38%	(26)
Nashville	19,854	(33)	18,385	(34)	0.30%	(34)	–7.40%	(27)
St Louis	95,555	(13)	88,201	(13)	1.45%	(13)	–7.70%	(28)
Kansas City	38,136	(24)	35,161	(27)	0.58%	(27)	–7.80%	(29)
Rochesterh	86,703	(14)	79,277	(15)	1.31%	(15)	–8.56%	(30)
Baltimore	61,732	(16)	55,378	(19)	0.91%	(19)	–10.29%	(31)
Orlando	33,565	(29)	29,793	(30)	0.49%	(30)	–11.24%	(32)
New York	115,904	(11)	102,801	(11)	1.69%	(11)	–11.31%	(33)
Boston	268,574	(2)	234,134	(3)	3.86%	(3)	–12.82%	(34)
Providence	19,080	(34)	16,597	(36)	0.27%	(36)	–13.01%	(35)
Los Angeles	436,065	(1)	374,781	(1)	6.17%	(1)	–14.05%	(36)
Tucson	20,975	(32)	16,999	(35)	0.28%	(35)	–18.96%	(37)
Total	3,292,633		3,200,210		52.70%		–2.81%	

*Ranked by growth rate
Source: U.S. Bureau of Labor Statistics, ES-202 data, Special Run

To control for the size of a metropolitan area, we introduce a new variable, labor force, to carry out a common size analysis. As the economic interest is the creation of jobs, it is crucial to compare jobs created or lost to the number of people who are able and willing to work (labor force). We define the controlled net relative growth as the net relative growth per 1000 persons in the labor force. Since the span of our study is 1988 and 1991, labor force refers to the average of the two years' labor force. Thus, equation (1) is modified as follows,

$$\text{CNRG}_j = \frac{\sum (r_{ij} - s)\ \text{HTEMP}_{ij}}{\text{LF}_j} \qquad \text{for } i = 1, \ldots, 6 \quad j = 1, \ldots, 37 \tag{2}$$

where

CNRG_j = Controlled net relative Growth of high technology employment for the metropolitan statistical area (MSA) j between 1988 and 1991,

LF_j = Average labor force for MSA j between 1988 and 1991.

The net relative growth is a measure of the shift of high technology jobs in and out of the economic activity of the metropolitan area. The net relative growth, which can be negative or positive, is determined by two factors: (1) industry mix and (2) the regional share or competitive component. The industry mix is itself influenced by growth in a given industry. The employment growth in a metropolitan area is affected positively or negatively by the performance of each individual industry that makes up its economy. These industries may have a higher or a lower growth rate than the national average. The following equation is used to calculate the industry mix:

$$\text{IM}_j = \sum (s_i - s)\ \text{HTEMP}_{ij} \qquad \text{for } i = 1, \ldots, 6 \quad j = 1, \ldots, 37 \tag{3}$$

where

s_i = employment growth rate for industry i for all MSAs,

IM_j = industry mix of high technology employment for MSA j.

The controlled industry mix is calculated by dividing the competitive component by the average labor force between 1988 and 1991. Thus, equation (3) becomes

$$\text{CIM}_j = \frac{\sum (s_i - s)\ \text{HTEMP}_{ij}}{\text{LF}_j} \qquad \text{for } i = 1, \ldots, 6 \quad j = 1, \ldots, 37 \tag{4}$$

where

CIM_j = Controlled industry mix of high technology employment for MSA j.

The other component of net relative growth is the competitive component. The competitive component measures the part of a metropolitan area's growth that is due to its competitiveness. For instance, two metropolitan areas may have the same industry structure and same industry mix, but may have different growth because one is more competitive than the other. Given the net relative growth and the industry mix, the competitive component is computed by subtracting equation (3) from equation (1). Therefore, the competitive component equation is:

$$\text{CC}_j = \sum (r_{ii} - s_j)\ \text{HTEMP}_{ij} \qquad \text{for } i = 1, \ldots, 6 \quad j = 1, \ldots, 37 \tag{5}$$

where

CC_j = Competitive component of the net relative growth for MSA j.

The controlled competitive component is calculated by dividing the competitive component by the average labor force between 1988 and 1991. Thus, equation (5) becomes

$$\text{CCC}_j = \frac{\sum (r_{ij} - s_i)\ \text{HTEMP}_{ij}}{\text{LF}_j} \qquad \text{for } i = 1, \ldots, 6 \quad j = 1, \ldots, 37 \tag{6}$$

where

CCC_j = Controlled competitive component of the net relative growth for MSA j.

The controlled components of shift-share are introduced to supplement the traditional shift-share. They are introduced to capture the performance of all MSAs and remove any bias that may be due to the size of the metropolitan area.

The shift-share technique answers three questions: (1) How is a metropolitan area doing compared to the national average? (2) What is the impact of industry mix on the metropolitan economy? and (3) How competitive is the metropolitan area? However, shift-share does not explain why the metropolitan area is growing. For a discussion of this, see Acs, FitzRoy, and Smith (1998).

The analysis below is different from previous shift-share analyses in that it views the growth of

high technology in both absolute and relative terms. Relative values should be understood as the values of controlled components of shift-share. In other words, relative values are absolute value per 1000 persons in the civilian labor force.

4. Regional analysis

Table II presents a summary of our results. The net relative growth indicates the number of jobs that should have moved in or out of the economy. The industry mix indicates how a region performed because of its industry mix, while the competitive component captures the number of jobs

TABLE II
Shift share analysis*

Metropolitan area:	Industry Mix				Competitive Component				Net Relative Growth			
	Absolute	Rank	Relative	Rank	Absolute	Rank	Relative	Rank	Absolute	Rank	Relative	Rank
Atlanta	(105)	(23)	–0.07	(22)	7,023	(7)	4.72	(10)	6,918	(7)	4.69	(11)
Austin	642	(10)	1.46	(4)	12,272	(3)	27.96	(1)	12,914	(3)	30.02	(1)
Baltimore	(129)	(24)	–0.11	(23)	(4,541)	(31)	–3.80	(30)	(4,670)	(29)	–3.97	(30)
Boston	156	(20)	0.10	(21)	(27,268)	(36)	–17.58	(37)	(27,112)	(36)	–17.38	(37)
Charlotte	539	(12)	0.85	(6)	3,474	(10)	5.47	(9)	4,013	(10)	6.40	(8)
Chicago	1,367	(5)	0.42	(14)	(6,979)	(33)	–2.17	(25)	(5,612)	(33)	–1.76	(25)
Cincinnati	(453)	(29)	–0.59	(28)	2,316	(14)	2.99	(12)	1,863	(17)	2.45	(14)
Cleveland	(633)	(31)	–0.67	(29)	2,511	(13)	2.67	(15)	1,878	(16)	2.01	(17)
Columbus	172	(18)	0.24	(19)	(92)	(21)	–0.13	(21)	80	(20)	0.11	(20)
Dallas	955	(8)	0.66	(11)	2,256	(15)	1.57	(16)	3,212	(13)	2.23	(15)
Denver	724	(9)	0.82	(9)	1,190	(18)	1.34	(18)	1,914	(15)	2.17	(16)
Houston	3,056	(2)	1.80	(2)	20,703	(2)	12.20	(4)	23,759	(2)	14.51	(4)
Indianapolis	168	(19)	0.25	(18)	1,968	(16)	2.91	(13)	2,136	(14)	3.18	(13)
Kansas City	465	(13)	0.54	(13)	(2,399)	(27)	–2.80	(26)	(1,934)	(25)	–2.28	(26)
Los Angeles	(7,378)	(37)	–1.70	(34)	(42,008)	(37)	–9.69	(34)	(49,385)	(37)	–11.86	(36)
Louisville	(952)	(34)	–1.87	(35)	318	(19)	0.62	(19)	(634)	(23)	–1.25	(23)
Miami	606	(11)	0.64	(12)	2,667	(12)	2.81	(14)	3,272	(12)	3.50	(12)
Minneapolis	146	(21)	0.10	(20)	(5,395)	(32)	–3.85	(31)	(5,249)	(31)	–3.79	(29)
Nashville	(288)	(27)	–0.54	(26)	(639)	(23)	–1.20	(24)	(927)	(24)	–1.73	(24)
New York	2,717	(3)	0.83	(8)	(12,657)	(35)	–3.87	(32)	(9,940)	(35)	–3.08	(27)
Orlando	(667)	(32)	–1.09	(33)	(2,189)	(26)	–3.58	(29)	(2,856)	(27)	–4.90	(31)
Philadelphia	2,026	(4)	0.84	(7)	(2,631)	(28)	–1.08	(23)	(605)	(22)	–0.25	(22)
Phoenix	(258)	(26)	–0.25	(25)	1,433	(17)	1.37	(17)	1,175	(18)	1.14	(18)
Pittsburg	339	(16)	0.34	(16)	(573)	(22)	–0.58	(22)	(234)	(21)	–0.24	(21)
Portland	(365)	(28)	–0.54	(27)	5,287	(9)	7.84	(6)	4,922	(9)	7.58	(6)
Providence	(63)	(22)	–0.18	(24)	(1,900)	(25)	–5.56	(33)	(1,962)	(26)	–5.71	(32)
Raleigh	1,097	(6)	2.65	(1)	8,060	(5)	19.47	(3)	9,157	(5)	22.93	(3)
Richmond	356	(15)	0.77	(10)	83	(20)	0.18	(20)	439	(19)	0.98	(19)
Rochester	(3,747)	(35)	–7.38	(37)	(1,762)	(24)	–3.47	(28)	(5,510)	(32)	–10.96	(34)
Saint Louis	(827)	(33)	–0.77	(31)	(3,919)	(30)	–3.08	(27)	(4,747)	(30)	–3.76	(28)
Salt Lake City	338	(17)	0.27	(17)	3,196	(11)	6.29	(7)	3,534	(11)	7.11	(7)
San Diego	(453)	(30)	–0.89	(32)	6,421	(8)	5.58	(8)	5,967	(8)	5.30	(10)
San Francisco	1,017	(7)	0.88	(5)	7,813	(6)	8.95	(5)	8,829	(6)	10.08	(5)
San Jose	359	(14)	0.41	(15)	(9,729)	(34)	–11.77	(36)	(9,370)	(34)	–11.17	(35)
Seattle	(4,203)	(36)	–5.08	(36)	29,763	(1)	27.74	(2)	25,560	(1)	24.74	(2)
Tucson	(235)	(25)	–0.75	(30)	(3,169)	(29)	–10.13	(35)	(3,404)	(28)	–10.85	(33)
Washington	3,514	(1)	1.59	(3)	9,096	(4)	4.12	(11)	12,609	(4)	5.77	(9)
Large-size MSAs	5,626		0.23		(61,779)		–2.54		(56,153)		–2.31	
Medium-size MSAs	(2,449)		–0.20		36,780		3.00		34,331		2.80	
Small-size MSAs	(3,177)		–0.41		24,999		3.76		21,822		3.34	

* Relative numbers refer to the number of employees per 1000 persons in civilian labor force.

gained or lost not because of the industry mix, but because the region is competitive. For the whole sample, 16 of the 37 MSAs had a negative industry mix; that is, they lost jobs because of the portfolio of their high tech industries. Seventeen regions lost high tech employment because of a lack of regional competitiveness.

Between 1988 and 1991 Los Angeles lost 49,385 jobs. Los Angeles lost 7,378 jobs partly because 48.4% of its high tech jobs are concentrated in the defense and aerospace industry, an industry in decline. However, the competitive components show that Los Angeles lost 42,000 jobs because of the poor competitiveness of the city. Seattle gained 25,560 jobs in the same period. It lost 4,203 jobs because it had an unfavorable mix of industries; however, it gained 29,762 jobs because of its overall competitiveness. Figures 1 ranks the metropolitan areas by competitiveness. It is clear that most of the employment losses come from a negative competitiveness component.

5. Sectorial analysis

Since industry mix refers to a portfolio of industries and is therefore applicable to total high technology industries, it should be understood as industry performance whenever the term is used for a particular industry. For example, job growth due to industry mix for the biotechnology and biomedical industry should be understood as job growth due to the performance of that industry in the nation. However, when this term is used for an MSA's total high technology industry, it refers to job growth due to the kind of mix (portfolio) making up a metropolitan area's high technology industry. An industry-by-industry analysis has proved necessary in this paper since each metropolitan area has its own strengths and weaknesses for each of the 6 industry groups. Those strengths and weaknesses may or may not appear in the aggregate results shown earlier. Tables III–V provide data on the 6 industry groups for 37 metropolitan areas.

The biotechnology and biomedical industry grew by 7.64% between 1988 and 1991. This high growth is reflected in the industry mix which is

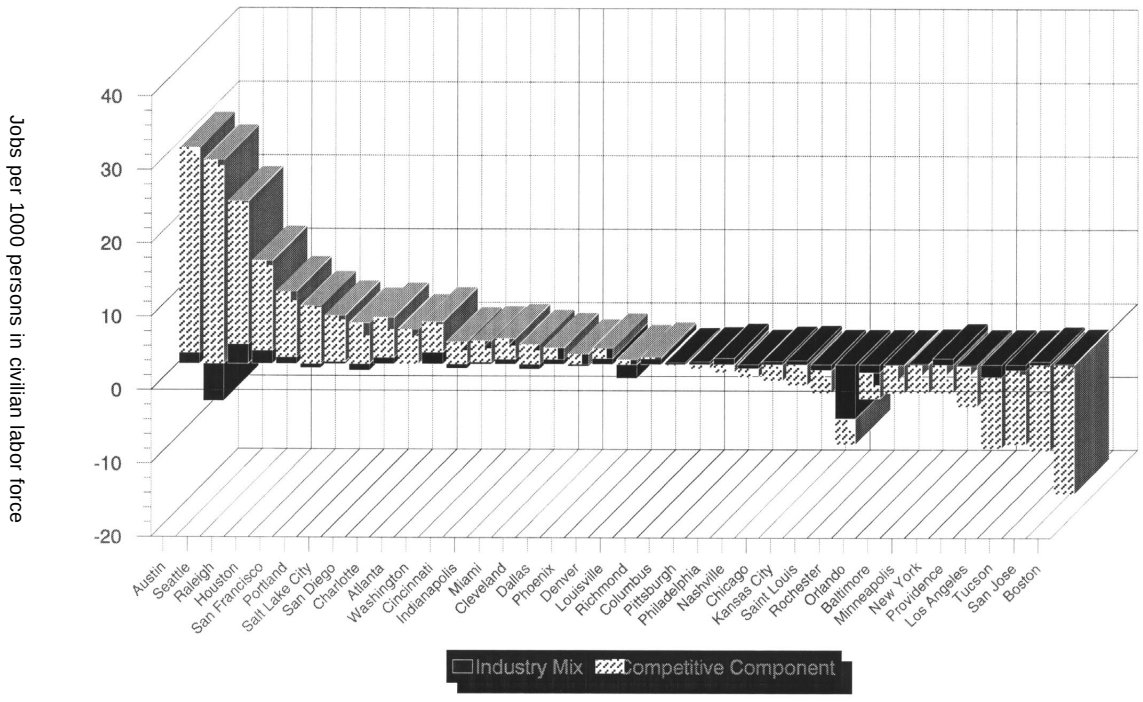

Fig. 1. High-technology employment growth in U.S. metropolitan areas (a shift share analysis).

TABLE III
Shift share analysis: net relative growth*

Metropolitan area	Biotechnology & Biomedical		Defence & Aerospace		Energy & Chemicals		Information Technology & Services		Machinery & Instruments		High Tech Research		Total High Tech Industries	
	Absolute	Relative*	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative
Atlanta	2,130	1.45	(2,860)	–1.94	34	0.02	5,116	3.47	1,373	0.93	1,125	0.76	6,918	4.69
Austin	820	1.91	NA	NA	NA	NA	10,025	23.30	939	2.18	1,131	2.63	12,914	30.02
Baltimore	982	0.83	(3,745)	–3.18	26	0.02	(1,500)	–1.27	(667)	–0.57	235	0.20	(4,670)	–3.97
Boston	25	0.02	(3,511)	–2.25	(326)	–0.21	(15,122)	–9.69	(7,933)	–5.09	(245)	–0.16	(27,112)	–17.38
Charlotte	310	0.50	(115)	–0.18	848	1.35	2,163	3.45	638	1.02	170	0.27	4,013	6.40
Chicago	(801)	–0.25	2,990	0.94	2,151	0.67	2,522	0.79	(6,899)	–2.16	(5,576)	–1.75	(5,612)	–1.76
Cincinnati	194	0.26	524	0.69	733	0.96	1,289	1.69	(341)	–0.45	(536)	–0.70	1,863	2.45
Cleveland	23	0.02	(305)	–0.33	805	0.86	1,262	1.35	(184)	–0.20	277	0.30	1,878	2.01
Columbus	155	0.22	(202)	–0.28	144	0.20	2,176	3.06	(1,218)	–1.71	(976)	–1.37	80	0.11
Dallas	792	0.55	(1,904)	–1.32	195	0.13	3,486	2.42	(154)	–0.11	796	0.55	3,212	2.23
Denver	144	0.16	(1,350)	–1.53	132	0.15	2,420	2.75	(115)	–0.13	684	0.78	1,914	2.17
Houston	213	0.13	1,446	0.88	6,627	4.05	8,384	5.12	5,973	3.65	1,117	0.68	23,759	14.51
Indianapolis	2,611	3.89	(299)	–0.45	73	0.11	(711)	–1.06	(243)	–0.36	705	1.05	2,136	3.18
Kansas City	(237)	–0.28	5,675	6.68	(46)	–0.05	(7,081)	–8.33	(726)	–0.85	480	0.56	(1,934)	–2.28
Los Angeles	(2,083)	–0.50	(32,177)	–7.73	(52)	–0.01	(6,639)	–1.59	(8,385)	–2.01	(50)	–0.01	(49,385)	–11.86
Louisville	173	0.34	NA	NA	NA	NA	1,124	2.22	(1,879)	–3.71	(52)	–0.10	(634)	–1.25
Miami	995	1.06	(85)	–0.09	(98)	–0.11	1,625	1.74	576	0.62	259	0.28	3,272	3.50
Minneapolis	2,876	2.08	(1,366)	–0.99	274	0.20	(6,851)	–4.94	11	0.01	(193)	–0.14	(5,249)	–3.79
Nashville	(22)	–0.04	(510)	–0.95	115	0.22	127	0.24	(772)	–1.44	133	0.25	(927)	–1.73
New York	573	0.18	(367)	–0.11	(994)	–0.31	(6,841)	–2.12	(4,191)	–1.30	1,880	0.58	(9,940)	–3.08
Orlando	(91)	–0.16	(4,630)	–7.95	(52)	–0.09	2,125	3.65	(5)	–0.01	(203)	–0.35	(2,856)	–4.90
Philadelphia	3,355	1.39	(687)	–0.28	2,339	0.97	(4,384)	–1.81	(2,437)	–1.01	1,210	0.50	(605)	–0.25
Phoenix	(990)	–0.96	2,028	1.97	229	0.22	(1,610)	–1.56	1,165	1.13	354	0.34	1,175	1.14
Pittsburg	284	0.29	(153)	–0.16	(903)	–0.94	1,197	1.24	(1,476)	–1.53	818	0.85	(234)	–0.24
Portland	526	0.81	225	0.35	164	0.25	5,471	8.43	(1,622)	–2.50	159	0.24	4,922	7.58
Providence	(6)	–0.02	(10)	–0.03	(461)	–1.34	651	1.89	(2,139)	–6.23	3	0.01	(1,962)	–5.71
Raleigh	1,178	2.95	NA	NA	NA	NA	5,575	13.96	860	2.15	1,544	3.87	9,157	22.93
Richmond	(433)	–0.97	NA	NA	NA	NA	(180)	–0.40	899	2.02	153	0.34	439	0.98
Rochester	584	1.16	NA	NA	NA	NA	1,213	2.41	(6,930)	–13.78	(377)	–0.75	(5,510)	–10.96
Saint Louis	(12)	–0.01	(6,416)	–5.08	1,691	1.34	(469)	–0.37	(218)	–0.17	678	0.54	(4,747)	–3.76
Salt Lake City	1,629	3.28	666	1.34	(112)	–0.23	203	0.41	58	0.12	1,089	2.19	3,534	7.11
San Diego	2,871	2.55	(446)	–0.40	(124)	–0.11	(378)	–0.34	2,319	2.06	1,726	1.53	5,967	5.30
San Francisco	201	0.23	(348)	–0.40	325	0.37	6,937	7.92	645	0.74	1,069	1.22	8,829	10.08
San Jose	1,612	1.92	(4,551)	–5.43	571	0.68	543	0.65	(6,609)	–7.88	(935)	–1.11	(9,370)	–11.17
Seattle	1,189	1.15	18,916	18.31	177	0.17	4,329	4.19	(283)	–0.27	1,232	1.19	25,560	24.74
Tucson	26	0.08	(1,258)	–4.01	32	0.10	(2,034)	–6.48	(490)	–1.56	320	1.02	(3,404)	–10.85
Washington	190	0.09	1,994	0.91	(335)	–0.15	6,498	2.97	497	0.23	3,766	1.72	12,609	5.77

* Relative numbers refer to the number of employees per 1000 persons in civilian labor force.

TABLE IV
Shift share analysis: industry mix*

Metropolitan area	Biotechnology & Biomedical		Defence & Aerospace		Energy & Chemicals		Information Technology & Services		Machinery & Instruments		High Tech Research	
	Absolute	Relative*	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative
Atlanta	274	0.18	(740)	–0.50	206	0.14	507	0.34	(497)	–0.33	145	0.10
Austin	245	0.56	NA	NA	NA	NA	421	0.96	(249)	–0.57	224	0.51
Baltimore	236	0.20	(964)	–0.81	240	0.20	322	0.27	(449)	–0.38	486	0.41
Boston	1,712	1.10	(1,988)	–1.28	311	0.20	2,418	1.56	(3,367)	–2.17	1,071	0.69
Charlotte	131	0.21	(12)	–0.02	500	0.79	227	0.36	(334)	–0.53	26	0.04
Chicago	1,162	0.36	(72)	–0.02	861	0.27	1,587	0.49	(3,773)	–1.17	1,603	0.50
Cincinnati	453	0.59	(884)	–1.14	352	0.46	145	0.19	(713)	–0.92	194	0.25
Cleveland	229	0.24	(372)	–0.40	743	0.79	196	0.21	(1,552)	–1.65	124	0.13
Columbus	172	0.24	(77)	–0.11	203	0.28	205	0.28	(647)	–0.89	316	0.43
Dallas	393	0.27	(1,318)	–0.91	981	0.68	1,542	1.07	(841)	–0.58	198	0.14
Denver	450	0.51	(694)	–0.78	776	0.87	280	0.32	(268)	–0.30	179	0.20
Houston	135	0.08	(42)	–0.02	3,808	2.24	397	0.23	(1,582)	–0.93	340	0.20
Indianapolis	1,146	1.69	(636)	–0.94	64	0.09	186	0.27	(727)	–1.07	135	0.20
Kansas City	547	0.64	(144)	–0.17	136	0.16	322	0.38	(505)	–0.59	109	0.13
Los Angeles	2,025	0.47	(10,021)	–2.31	1,256	0.29	1,684	0.39	(3,670)	–0.85	1,349	0.31
Louisville	45	0.09	NA	NA	NA	NA	66	0.13	(1,116)	–2.19	53	0.10
Miami	722	0.76	(103)	–0.11	43	0.05	89	0.09	(191)	–0.20	46	0.05
Minneapolis	1,264	0.90	(686)	–0.49	139	0.10	1,080	0.77	(1,903)	–1.36	251	0.18
Nashville	99	0.18	(153)	–0.29	98	0.18	118	0.22	(464)	–0.87	14	0.03
New York	1,824	0.56	(220)	–0.07	374	0.11	897	0.27	(1,175)	–0.36	1,017	0.31
Orlando	87	0.14	(677)	–1.11	13	0.02	208	0.34	(353)	–0.58	55	0.09
Philadelphia	2,390	0.99	(892)	–0.37	1,249	0.51	1,081	0.45	(2,267)	–0.93	465	0.19
Phoenix	217	0.21	(1,174)	–1.13	34	0.03	874	0.84	(346)	–0.33	137	0.13
Pittsburg	299	0.30	(12)	–0.01	417	0.42	225	0.23	(975)	–0.99	384	0.39
Portland	208	0.31	(107)	–0.16	36	0.05	311	0.46	(921)	–1.37	107	0.16
Providence	194	0.57	(5)	–0.01	117	0.34	120	0.35	(516)	–1.51	27	0.08
Raleigh	600	1.45	NA	NA	NA	NA	521	1.26	(335)	–0.81	312	0.75
Richmond	274	0.60	NA	NA	NA	NA	100	0.22	(62)	–0.13	43	0.09
Rochester	570	1.12	NA	NA	NA	NA	163	0.32	(4,567)	–8.99	86	0.17
Saint Louis	811	0.76	(2,140)	–1.99	696	0.65	269	0.25	(646)	–0.60	183	0.17
Salt Lake City	386	0.30	(325)	–0.26	110	0.09	276	0.22	(186)	–0.15	77	0.06
San Diego	642	1.26	(1,424)	–2.80	70	0.14	585	1.15	(943)	–1.86	617	1.21
San Francisco	402	0.35	(92)	–0.08	173	0.15	318	0.28	(165)	–0.14	380	0.33
San Jose	1,071	1.23	(1,687)	–1.93	45	0.05	2,792	3.20	(2,691)	–3.08	829	0.95
Seattle	385	0.47	(4,655)	–5.63	25	0.03	297	0.36	(530)	–0.64	274	0.33
Tucson	58	0.19	(356)	–1.14	4	0.01	165	0.53	(165)	–0.53	59	0.19
Washington	127	0.06	(163)	–0.07	103	0.05	1,664	0.75	(272)	–0.12	2,054	0.93

* Relative numbers refer to the number of employees per 1000 persons in civilian labor force.

TABLE V
Shift share analysis: competitive component*

Metropolitan area	Biotechnology & Biomedical		Defence & Aerospace		Energy & Chemicals		Information Technology & Services		Machinery & Instruments R		High Tech esearch	
	Absolute	Relative*	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative	Absolute	Relative
Atlanta	1,856	1.25	(2,119)	–1.42	(172)	–0.12	4,609	3.09	1,870	1.26	980	0.66
Austin	574	1.31	NA	NA	NA	NA	9,603	21.88	1,187	2.70	907	2.07
Baltimore	746	0.62	(2,781)	–2.33	(214)	–0.18	(1,821)	–1.52	(218)	–0.18	(252)	–0.21
Boston	(1,687)	–1.09	(1,523)	–0.98	(636)	–0.41	(17,540)	–11.31	(4,566)	–2.94	(1,316)	–0.85
Charlotte	180	0.28	(103)	–0.16	348	0.55	1,935	3.04	972	1.53	143	0.23
Chicago	(1,963)	–0.61	3,062	0.95	1,290	0.40	936	0.29	(3,126)	–0.97	(7,179)	–2.23
Cincinnati	(259)	–0.33	1,408	1.82	381	0.49	1,144	1.48	372	0.48	(730)	–0.94
Cleveland	(205)	–0.22	67	0.07	62	0.07	1,066	1.13	1,369	1.46	153	0.16
Columbus	(16)	–0.02	(125)	–0.17	(59)	–0.08	1,971	2.71	(571)	–0.78	(1,292)	–1.78
Dallas	399	0.28	(586)	–0.41	(786)	–0.55	1,944	1.35	687	0.48	598	0.41
Denver	(307)	–0.35	(657)	–0.74	(643)	–0.73	2,140	2.41	153	0.17	504	0.57
Houston	78	0.05	1,488	0.88	2,819	1.66	7,987	4.71	7,555	4.45	777	0.46
Indianapolis	1,464	2.16	337	0.50	9	0.01	(897)	–1.32	483	0.71	570	0.84
Kansas City	(784)	–0.92	5,819	6.80	(182)	–0.21	(7,402)	–8.65	(221)	–0.26	371	0.43
Los Angeles	(4,108)	–0.95	(22,155)	–5.11	(1,308)	–0.30	(8,323)	–1.92	(4,715)	–1.09	(1,399)	–0.32
Louisville	128	0.25	NA	NA	NA	NA	1,058	2.07	(763)	–1.50	(105)	–0.21
Miami	273	0.29	18	0.02	(141)	–0.15	1,536	1.62	767	0.81	213	0.22
Minneapolis	1,612	1.15	(680)	–0.48	135	0.10	(7,931)	–5.65	1,914	1.36	(444)	–0.32
Nashville	(121)	–0.23	(357)	–0.67	17	0.03	9	0.02	(308)	–0.58	120	0.22
New York	(1,251)	–0.38	(147)	–0.05	(1,368)	–0.42	(7,738)	–2.37	(3,016)	–0.92	862	0.26
Orlando	(178)	–0.29	(3,953)	–6.46	(66)	–0.11	1,917	3.13	348	0.57	(258)	–0.42
Philadelphia	965	0.40	205	0.08	1,090	0.45	(5,465)	–2.25	(170)	–0.07	745	0.31
Phoenix	(1,207)	–1.16	3,202	3.07	195	0.19	(2,484)	–2.38	1,511	1.45	216	0.21
Pittsburg	(15)	–0.02	(141)	–0.14	(1,320)	–1.34	971	0.99	(501)	–0.51	433	0.44
Portland	318	0.47	331	0.49	128	0.19	5,160	7.66	(702)	–1.04	52	0.08
Providence	(200)	–0.58	(5)	–0.01	(578)	–1.69	530	1.55	(1,623)	–4.75	(24)	–0.07
Raleigh	578	1.40	NA	NA	NA	NA	5,054	12.20	1,196	2.89	1,233	2.98
Richmond	(707)	–1.54	NA	NA	NA	NA	(280)	–0.61	960	2.09	109	0.24
Rochester	14	0.03	NA	NA	NA	NA	1,050	2.07	(2,363)	–4.65	(463)	–0.91
Saint Louis	(824)	–0.65	(4,276)	–3.36	995	0.78	(738)	–0.58	429	0.34	495	0.39
Salt Lake City	1,242	2.45	991	1.95	(221)	–0.44	(73)	–0.14	244	0.48	1,013	1.99
San Diego	2,229	1.94	978	0.85	(194)	–0.17	(963)	–0.84	3,262	2.83	1,108	0.96
San Francisco	(201)	–0.23	(257)	–0.29	152	0.17	6,619	7.58	810	0.93	689	0.79
San Jose	541	0.65	(2,864)	–3.46	526	0.64	(2,249)	–2.72	(3,918)	–4.74	(1,764)	–2.13
Seattle	804	0.75	23,571	21.97	152	0.14	4,031	3.76	247	0.23	958	0.89
Tucson	(32)	–0.10	(903)	–2.89	28	0.09	(2,199)	–7.03	(325)	–1.04	262	0.84
Washington	62	0.03	2,157	0.98	(438)	–0.20	4,834	2.19	769	0.35	1,712	0.78

* Relative numbers refer to the number of employees per 1000 persons in civilian labor force.

positive for all MSAs under study. The findings reveal that this particular industry experienced sustained growth during the period under study. However, the competitive component which captures the growth due to the competitiveness of the MSA rather than the industry tells a different story. Five large MSAs, Los Angeles, Chicago, Boston, New York, and Phoenix, lost more than 1,200 jobs each due to competition; while San Diego, Atlanta, Minneapolis, and Indianapolis gained more than 1,400 jobs each.

As argued earlier, although it is important to know the gains and losses in absolute terms, the employment growth in small and medium metropolitan areas is neglected if no analysis is conducted in relative terms. Metropolitan areas like Salt Lake City and Indianapolis gained more than 2 jobs per 1,000 persons in the labor force due to competition. This is by far the greatest gain if the size of labor force is considered. Fortunately for this industry, only 3 metropolitan areas – Richmond, Phoenix, and Boston – lost more than 1 job per 1,000 persons in the labor force. Overall, Salt Lake City, Indianapolis, and Raleigh/Durham dominated the growth of the biotechnology and biomedical industries. Raleigh/Durham's strengths are conspicuous in industry mix.

The defense and aerospace industry experienced a large decline (–7.29%) during the period under study. The decline in this particular industry affected Los Angeles and Seattle more than any other metropolitan areas. The two lost more than 14,500 jobs due to the industry mix. However, in terms of competitiveness, Seattle gained 23,571 jobs while Los Angeles lost 22,155. For that reason, the trend in the defense and aerospace industry affected Seattle less than any other metropolitan area. Other MSAs with a high competitive advantage include Kansas City, Chicago, Phoenix, Washington, Houston, and Cincinnati. On the opposite side, Saint Louis, Orlando, San Jose, Baltimore, and Atlanta lost a considerable number of jobs due to competition.

Relatively speaking, Seattle gained approximately 20 jobs per 1000 persons in the labor force because of its competitiveness, although 5 jobs were lost because of a weak industry performance. Overall, Los Angeles and Orlando each lost 8 jobs per 1,000 persons in the labor force. It is worth mentioning that in absolute terms, Tucson lost 1,258 jobs, a number that is reasonable since it lost fewer jobs than 12 other MSAs. However, because of the small size of the metropolitan area, Tucson is ranked 5th in terms of jobs lost per 1000 persons in the labor force (4 jobs).

The energy and chemicals industry experienced a positive growth (2.69%) between 1988 and 1991. Houston, which had 8.5% of the U.S. energy and chemicals industry, experienced the highest growth due to industry mix with 3,808 jobs gained. Los Angeles and Philadelphia have also benefitted from the strengths of the energy and chemicals industry by gaining more than 1,200 jobs each. Just as in other high tech industries, Los Angeles did poorly in terms of competitive advantage. Los Angeles, along with Pittsburgh and New York, lost more than 1,000 jobs due to regional share. On the other hand, Houston, Chicago, and Philadelphia each had substantial gains of more than 1,000 jobs. Controlling for the size of labor force, Houston is also the leader in the energy and chemicals industry growth, followed by Charlotte and St. Louis. Providence and Pittsburgh performed worse than any other metropolitan area under study.

Information technology is an industry with a high concentration of jobs in San Jose, Boston, Washington, Chicago, Los Angeles, and Dallas. These MSAs are also the greatest gainers of jobs due to the high growth in this industry during the last 10 years. However, all these MSAs except Washington and Dallas experienced job losses due to competition. Austin and Houston gained more than 7,000 jobs each due to their competitiveness. Controlling for the size of labor force, Austin is by far the best performer in the information technology and services industry. Between 1988 and 1991, Austin gained 21 jobs per 1,000 persons in the labor force. Raleigh/Durham, Portland, and San Francisco gained 12, 8, and 8, respectively. At the same time, Boston, Kansas City, and Tucson lost 11, 8, and 7 jobs per 1,000 persons in the labor force.

High technology machinery is an industry heavily concentrated in Rochester, Chicago, and Los Angeles. These MSAs experienced a decline due to the poor performance of this industry at the national level. There was a 9.21% job decline in this industry, almost 2% more than in the defense industry. Other losers include Boston,

Philadelphia, and San Jose. Houston is the greatest winner of the competition with 7,555 jobs added between 1988 and 1991. The same metropolitan area stays the most competitive in the industry if labor force is controlled. Other good performers include Raleigh/Durham, San Diego, Austin, and Richmond. As a small-size MSA, Providence lost a great deal of jobs in this industry.

One out of ten employees in high technology research works in the Washington metropolitan area. This MSA, along with Chicago, Los Angeles, New York, and Boston has benefitted from the high growth in this particular industry. However, with the exception of Washington, the other MSAs did poorly in terms of competition. Washington is by far the most competitive MSA in this industry, followed by Raleigh/Durham, San Diego and Salt Lake City. The competitiveness of Washington is not obvious when labor force is controlled. In that regard, Raleigh/Durham and Salt Lake City are growing faster than Washington. Chicago, San Jose, and Columbus are losing their competitive edge.

6. Shift share and the MSA size

What is the right-size MSA for high tech industry? It appears that it depends on the industry. As shown in Table VI, in biotechnology small-size MSAs perform better than medium and large-size ones. For example, the net relative gain in small-size MSAs was 137 jobs per 100,000 persons in the labor force compared with 60 for medium-size MSAs and 30 for large-size MSAs. In defense and aerospace medium-size MSAs perform better than small and large-size MSAs. In high technology research, small-size MSAs perform better than medium and large-size MSAs. In high tech machinery, small-size MSAs dominate the industry in terms of growth. In information technologies, small-size MSAs outperform medium and large-size MSAs. Finally, in the energy and chemicals industry, large MSAs perform better than medium-size and small-size MSAs.

7. Conclusion

This paper illustrates the two perspectives of high technology employment in 37 MSAs. Absolute

TABLE VI
Shift share analysis by size of metropolitan area

Industry		Competitive component			Industry mix			Net relative growth		
		Large-size	Medium-size	Small-size	Large-size	Medium-size	Small-size	Large-size	Medium-size	Small-size
Biotechnology & Biomedical	Absolute	(4,860)	1,599	3,261	12,116	5,824	4,044	7,257	7,423	7,305
	Relative*	–0.20	0.13	0.61	0.50	0.47	0.76	0.30	0.60	1.37
Defence & Aerospace	Absolute	(24,575)	28,236	(3,661)	(18,281)	(12,280)	(2,270)	(42,857)	15,956	(5,931)
	Relative	–1.01	2.30	–0.69	–0.75	–1.00	–0.43	–1.76	1.30	–1.12
Energy & Chemical	Absolute	1,620	(1,285)	(335)	9,984	3,256	942	11,604	1,971	607
	Relative	0.07	–0.10	–0.05	0.41	0.27	0.14	0.48	0.16	0.09
Information Technology & Services	Absolute	(27,426)	4,559	22,867	13,125	6,650	2,884	(14,301)	11,209	25,751
	Relative	–1.13	0.37	3.45	0.54	0.54	0.44	–0.59	0.91	3.89
Machinery & Instruments	Absolute	(2,370)	3,062	(693)	(19,993)	(9,976)	(9,993)	(22,363)	(6,913)	(10,686)
	Relative	–0.10	0.25	–0.10	–0.82	–0.81	–1.51	–0.92	–0.56	–1.61
High Tech Research	Absolute	(4,168)	608	3,560	8,675	4,077	1,217	4,507	4,685	4,777
	Relative	–0.17	0.05	0.54	0.36	0.33	0.18	0.19	0.38	0.72
Total High Tech	Absolute	(61,779)	36,780	24,999	5,626	(2,449)	(3,177)	(56,153)	34,331	21,822
	Relative	–2.54	3.00	3.76	0.23	–0.20	–0.41	–2.31	2.80	3.34

* Relative numbers refer to the number of employees per 1000 persons in civilian labor force.

values are used when one wants to pinpoint the magnitude of employment losses and gains. No matter how big a metropolitan area is, one loss of a job is always detrimental to the economy. Economists are tempted to find out why jobs are lost or gained in one region and not in the other. Those losses or gains can only be measured with absolute numbers.

Large and small metropolitan areas may have different effects on job losses or gains. This paper also calculates the magnitude of these losses or gains by taking labor force as a control variable. The results of this study also help identify the effects of high technology trends on U.S. metropolitan areas. It should be mentioned that the labor force variable can be replaced by any other meaningful variable depending on the analysis. The key is to carry out an analysis based on results with the same unit. This paper identifies which metropolitan areas are weak or strong in which industries and how the industry portfolio of each MSA affects performance in its total high technology employment. Since 1991 was a recession year, additional research should be conducted with post-recession data.

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Appendix A: industry groupings

1. Biotechnology and Biomedical

283 Medicinal and Botanical
384 Medical Instruments and supplies
385 Ophthalmic Goods

2. Information Technology and Services

357 Computer and Office Equipment
361 Electronic Distribution Equipment
365 Audio and Video Equipment
366 Communications Equipment
367 Electronic Components and Accessories
489 Communication Sevices, nec
737 Computer and Data Processing

3. High Technology Machinery and Instruments

351 Engines and Turbines
353 Construction and Related Machinery
356 General Industrial Machinery
362 Electrical Industrial Apparatus
363 Household Appliances
364 Electric Lighting and Wiring
369 Miscellaneous Electrical Equipment and Suppliers
382 Measuring and Controlling Devices
386 Photographic Equipment and Supplies

4. Defence and Aerospace

348 Ordnance and Accessories, nec
372 Aircraft and Parts
376 Guided Missiles and Space
381 Search and Navigation Equipment

5. Energy and Chemicals

131 Crude Petroleum and Natural Gas
281 Industrial Inorganic Chemicals
282 Plastic Materials and Synthetics
286 Industrial Organic Chemicals
289 Miscellaneous Chemical Products
291 Petroleum Refining

6. High Technology Research

873 Research Development and Testing Services

Source: Office of Management and Budget , Standard Industrial Classification Manual (1987), Washington, DC 1988.

Appendix B: metropolitan area groupings

Large-Sized MSAs

Los Angeles
Chicago
Washington
Boston
Dallas
St Louis
New York
Philadelphia
Houston
Atlanta
Minneapolis/St.Paul

Medium-Sized MSAs

Baltimore
Seattle
Pittsburgh
Cleveland
San Francisco
San Jose
Columbus
San Diego
Phoenix
Miami
Denver
Kansas City
Cincinnati

Small-Sized MSAs

Indianapolis	Portland
Charlotte	Orlando
Nashville	Louisville
Salt Lake City	Rochester
Richmond	Austin
Raleigh/Durham	Providence
Tucson	

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