Income Distribution and the Information Technology Bubble

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Abstract

This paper explores the relationship between the between-groups component of Theil's T Statistic measured across U.S. counties using Local Area Personal Income Statistics, and the information technology bubble of the 1990s. Our examination yields a predictable result: the technology boom had a major effect on the distribution of income in the United States. The surprising fact is that higher incomes in a mere handful of counties influence aggregate measures so dramatically.

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I. Introduction

This short paper explores the relationship between two hallmark phenomena of the late 1990s, the rise in income inequality and the information technology bubble. From January 1994 to February 2000, the NASDAQ composite index rose from 776.80 to 4,696.69, a 605% increase, heavily influenced by prices of high-technology stocks. Meanwhile, some sociologists, applied economists, and public intellectuals called for increased attention to rising CEO compensation, living wage campaigns, the morphing of the service sector into the "servant class", and other issues of income inequality, while others celebrated the new scientific and technological paradigm as a driving force behind prosperity into the future. But the exact relationship between the technology boom and the inequality crisis remained at least partly obscure. This paper clarifies some of the issues, using Local Area Personal Income Statistics and the between-groups component of Theil's T statistic to measure the geographic dispersion of average income changes over place and time, and to relate the resulting measures of inequality with the information technology bubble.

The paper is organized in the following way. Section II gives a brief summary of methods and data. Section III discusses the geographic dispersion of income changes in the late 1990s in relation to the information technology bubble. Section IV asks, what would have happened to geographic inequality if the bubble had not happened? Section V offers brief conclusions and directions for further work.

II. Data and Measurement.

Our data come from the Regional Economics Accounts of the Bureau of Economic Analysis, an agency of the U.S. Department of Commerce.[1] Specifically, we use the Local Area Personal Income Statistics, which provide annual measures of income and population by county for the years 1969 – 2001. For the most part, each county in each state has an income and population figure for each year.[2]

There are several ways to measure income inequality. The well-known Gini coefficient has attractive attributes, foremost of which is an intuitive interpretation. However, the Gini relies on data collected at the micro-level, and organized into a ranked list; and such data are unavailable for the high level of geographic disaggregation with which we are concerned.

When data are grouped into mutually exclusive categories and/or placed in a data hierarchy, the between-groups component of Theil's T statistic is often a more useful inequality measure. For this paper, we compare the average income of each county-unit in the United States to the countrywide average and weight each county by its population, for each year in the data set.

The formula is thus:

$$T'_{Counties} = \sum_{i=1}^{m} \frac{p_i}{P} * \frac{y_i}{\mu} * \ln\left(\frac{y_i}{\mu}\right)$$

where T'_{Counties} is between-county inequality for the United States, p_i is the population of a county indexed by i, P is the total population of the United States, y_i is the average income for county i, and μ is the average income for the United States.

The between-county measure T'_{Counties}, shown in Figure 1, serves as a summary (lower-bound) measure of total inequality in the U.S. income distribution. It is admittedly a rough estimate, ignoring all variation among individuals within counties. However, the overall movement of the series tracks the standard survey-based measure of income inequality in the U.S. reasonably well; both series show rising income inequality at the end of the 1980s and again at the end of the 1990s.

<Figure 1 goes here>

The particular virtue of the Theil statistic in this context is that it allows us to isolate the effect of each and every county separately on the whole distribution. Since the Current Population Survey is limited to 60,000 households and there are more than 3,000 counties, this is obviously not possible with survey data even if one had county codes attached to each observation. With Theil's T the exercise is simple: the terms within the summation are known as the Theil elements, and allow us to parse the between-county measure across counties.

An element can be positive or negative. If a county's average income is greater than the national average, it will be positive, otherwise zero (if equal to the average), or negative (if below). Population weights also matter. Counties that are far above the national average income and have large populations will have large positive Theil elements, counties with average incomes well below the national average income and large populations will have large negative Theil elements. Counties with small populations will have Theil elements with small absolute values.

By construction, the sum of the positive elements must be greater than the sum of the negative elements, so that the aggregate between-county Theil index is always positive. Values can range in theory from zero (where every county has the same mean income) to log ($P/p_i(min)$), the logarithm of the total population size divided by the size of the smallest county (this value is attained when the smallest county holds all the wealth).

The value of the aggregate between-county inequality measure for a given year is largely uninterpretable, and so are the elements attributed to individual counties when taken in isolation. For instance, in 2000, the between-county T' was 0.04402 and individual elements ranged from -0.00139 for San Bernadino County, California to 0.01801 for New York County, New York. However, looking at changes over time in these numbers yields significant insight into broad shifts in inequality. As Figure 1 indicates, in the late 1960s and early 1970s cross-county inequality declined, before stabilizing through the early 1980s. The mid 1980s saw a rise in inequality, which was mitigated in the late 1980s and early 1990s. The period from 1994 to 2000 marks the period of largest inequality growth, a 48% increase in the between-county index. In 2001, the index began again to decline, and future data will indicate whether this is a brief interruption of the previous trend, or the beginning of a new one.

For the purposes of looking at linkages between the information technology bubble and inequality, it is useful to see how particular counties are contributing to the aggregate inequality level. Geographic Information Systems are particularly useful for this purpose, though black and white images cannot do justice to the output. Figure 2 shows a map of all the counties in the contiguous United States. All the counties that had positive Theil elements in the year 2000 (in other words, above-average per capita incomes) are colored black. Figure 2 indicates that only a select few counties are contributing positive Theil elements, while the vast majority of counties have average incomes at or below the national average. This is a characteristic pattern in all years, though the identity of the positive contributors changes and the number shrinks dramatically as the information technology bubble develops. An annual analysis using colored maps may be found on the web-site of the University of Texas Inequality Project at http://utip.gov.utexas.edu .

<Figure 2 Goes Here.>

III. The Information Technology Bubble and Inequality

For those who have wondered whether there can be "too much of a good thing," the information technology bubble is an example of just such a phenomenon. According to Robert Shapiro, former Undersecretary of Commerce,

> "The American bubble represented an excess of something that in itself has real value for the economy -- information technologies. The bubble began in overinvestment in IT and spread to much of the stock market; but at its core, much of the IT was economically sound and efficient. Further, these dynamics

> also played a role in the capital spending boom of the 1990s, and much of that capital spending translated into permanently higher productivity. The result is that the American bubble should not do lasting damage to the American economy."[3]

Computer programmers that have been laid off several times in the last year or two may take little solace from Shapiro's account, but his view is widely shared. The marketing people at Microsoft, Dell, and Amazon convinced enough people that Windows, desktop computers, and online shopping were going to fundamentally change everything about business. Technology promoters contended that anyone who would not buy in to the new technologies with due haste would be left behind. The mass hysteria resulted in a run-up in stock prices that defied logical explanation. Figure 3 plots the monthly close of the Nasdaq Composite Index from 1984 though September 2003. The Nasdaq is known as a "tech-heavy" exchange, but as Shapiro points out the run-up in technology stocks carried over into the broader market. The period from 1994 to 2000 was one of solid overall economic growth, while from mid-2000 through 2001, most of the stock gains evaporated and the economy slowed down.

<Figure 3 goes here>

Figures 1 and 3 make a *prima facie* case that the bubble and the rise in income inequality were related. As high-tech firms' stock prices shot upwards, their employees and stockholders reaped tangible benefits. If employment in the technology sector were uniformly distributed across space, this would have had little impact on a between-counties measure of inequality. But it wasn't. We know that technology firms are not distributed uniformly, but are clustered in centers such as Silicon Valley, Seattle, North

Carolina's Research Triangle, Austin, and Boston's Route 128 Corridor. Thus, one might expect that over the period from 1994 – 2000, the growth in the Theil elements associated with the main high-tech counties would be a significant force behind changes in the aggregate Theil Index. We show below that this was, in fact, the case.

A first step is to identify those counties that had large changes in their Theil elements during the bubble. Table 1 lists the 10 counties with the largest increases in their Theil elements and the 10 counties with the largest decreases in their Theil elements from 1994 – 2000.

Table 1:

Counties with the largest positive changes in Theil Elements 1994 – 2000	
County, State	**Theil Element Change 1994 - 2000**
New York, New York	0.00517211
Santa Clara, California	0.00468738
San Mateo, California	0.00208153
King, Washington	0.00169613
San Francisco, California	0.00148821
Harris, Texas	0.00147724
Middlesex, Massachusetts	0.00131529
Fairfield, Connecticut	0.00099520
Alameda, California	0.00088503
Westchester, New York	0.00086216

Counties with the largest negative changes in Theil Elements 1994 - 2000	
County, State	**Theil Element Change 1994 - 2000**
Los Angeles, California	-0.00089362
Queens, New York	-0.00070519
Honolulu, Hawaii	-0.00065515
Broward, Florida	-0.00056938
Cuyahoga, Ohio	-0.00036473
Kings, New York	-0.00034178
Miami-Dade, Florida	-0.00032742
San Bernardino, California	-0.00031665
Genesee, Michigan	-0.00031147
Clark, Nevada	-0.00030658

Are the counties on the left side of the table – Santa Clara, San Mateo, King (Washington), Middlesex, Fairfield -- more technologically-driven than those on the right side? Without question. Big gains occur around areas of the country known to have a hi-tech emphasis (e.g. Silicon Valley, Seattle, and Boston), while losses occur in rust belt counties (Flint MI, Cleveland OH) and counties heavily reliant on (in the instant case, Japanese) tourism (Honolulu). Several smaller counties in areas of the country also known to have a strong technological emphasis (e.g. Raleigh NC, Austin TX, and Boulder CO) have Theil element gains that rank in the top 50.

A simple way to identify counties that are (or were) economically driven by information technology is to see where hi-tech firms are located. There are many lists of such firms, but one particularly good one is the CNET Tech Index composed of 84 Internet, computer manufacturing, and other information technology companies,[4] which is a who's who list of technological giants. Eighty of eighty-four firms listed on the CNET Tech Index are headquartered in the United States. Half of these companies are headquartered in counties that were among the top-10 largest gainers in Theil element from 1994 – 2000.[5] While this figure is skewed by Santa Clara County, where 26 of the 80 companies reside, 8 of the top-10 counties had at least one leading hi-tech firm. On the other side of the spectrum, the 10 counties that saw their Theil element erode the most from 1994 – 2000 contained company headquarters for only 2 CNET Tech Index firms.[6]

This analysis indicates that the performance of the information technology sector may be a significant determinant of the movement of income inequality as a whole during this time. In the period when inequality grew most significantly, the counties most responsible for aggregate changes were those with strong technology sectors. But, we also know that between-county inequality *decreased* between 2000 and 2001. If technology really is a big part of the story, then we might expect that the counties where

Theil elements were growing most rapidly from 1994 – 2000 would see their elements decline significantly from 2000 – 2001. Table 2 lists the 10 counties with the largest decreases in their Theil elements and the 10 counties with the largest increases in their Theil elements from 2000 - 2001.

Table 2:

Counties with the largest negative changes in Theil Elements 2000 - 2001		**Counties with the largest positive changes in Theil Elements 2000 - 2001**	
County, State	**Theil Element Change 2000 - 2001**	**County, State**	**Theil Element Change 2000 - 2001**
Santa Clara, California	-0.00168036	New York, New York	0.00048097
San Mateo, California	-0.00066027	Los Angeles, California	0.00039629
Dallas, Texas	-0.00042349	Harris, Texas	0.00038605
DuPage, Illinois	-0.00033057	Fairfax, Virginia	0.00019027
King, Washington	-0.00021691	Allegheny, Pennsylvania	0.00018010
Collin, Texas	-0.00018728	Orange, California	0.00017505
Contra Costa, California	-0.00018602	Palm Beach, Florida	0.00015951
Kings, New York	-0.00016389	Montgomery, Maryland	0.00013561
Alameda, California	-0.00015011	Cook, Illinois	0.00013094
Oakland, Michigan	-0.00012203	San Diego, California	0.00009651

Once again, we ask whether the left side of the table contains counties more dependent on the hi-tech economy than the right? The evidence is less overwhelming than for Table 1, but it still supports the hypothesis. Santa Clara, the most tech-driven county in the country, is the biggest, and 3 other Silicon Valley counties are in the top-10 list, along with King County Washington, home of Microsoft. The list of the fifty counties that saw the biggest Theil element declines include counties surrounding tech centers like Boston, Denver, Austin, and Boise ID. The counties on the right side of Table 2, on the other hand, include some of the largest metropolitan areas in the country (New York, Los

Angeles, Chicago, Houston). While each of these areas may have some hi-tech companies, the local economies are not tied as directly to the tech sector as the counties on the left of the table.

The number of hi-tech firms headquartered in the counties with large changes in their Theil elements from 2000 – 2001 follows the expected pattern. Thirty-seven of the CNET Tech Index companies are headquartered in counties that were among the top-10 largest losers in Theil Index element from 2000 – 2001, including Santa Clara County. Forty-six of the eighty CNET companies are headquartered in the fifty counties that had the largest decreases in their Theil elements from 2000 to 2001. The ten counties that saw their Theil element gain the most from 2000 to 2001 host headquarters for 11 CNET Tech Index firms. Seventeen of the eighty CNET companies are headquartered in the fifty counties that had the largest increases in their Theil elements from 2000 - 2001. However, most of these companies are headquartered in New York, Los Angeles, San Diego, or Chicago, which have heterogeneous economies.

IV. A Counterfactual Example

The previous section argues that the information technology bubble was closely associated with the rise in aggregate inequality in the late 1990's. Furthermore, the bubble was a localized phenomenon, where a few hi-tech centers reaped most of the gains. A thought experiment along these lines might ask, what would have happened if four hi-tech counties (Santa Clara, San Mateo, and San Francisco Counties in California and King County, Washington) had not seen per capita incomes explode, but had instead experienced more moderate growth? The results are quite impressive. Substituting per capita incomes for these 4 counties that grow along with the average nationwide increase in per capita income from 1994 – 2000 -- an average of 4.7% per annum -- results in an aggregate inequality curve that is basically flat, as shown in Figure 4. These four counties are so important to the between-county Theil index, in other words, that their income changes drive the aggregate figures that sum over 3100 counties.

<Figure 4 Goes Here>

It is worthwhile to close this section with a small cautionary note. Since we do not have a measure of inequality within counties, it is quite possible that rising inequality inside large metropolitan areas would continue to drive overall income inequality upwards, even if all residents of these four counties were deleted from a national sample. Our point is only that the entire increase in the *geographic* dispersion of income over the late 1990s is accounted for by these four places alone.

V. Conclusions and Next Steps

We conclude with a point that borders on the painfully obvious: the information technology bubble of the 1990s had a major effect on the geographic dispersion of income in the country, and this effect was driven very largely by the impact of dramatically higher incomes in a very small number of places.

Of course, it is also true (and notoriously well known) that these events had a dramatic effect on living costs in those places, and that they also rearranged the migratory patterns associated with them: for instance by forcing low-income people to live elsewhere. It is nevertheless striking how in a huge continental economy like that of the United States so much income change could be concentrated in such a tiny fraction of the available space. That so much of this space was located in California was, of course, a major factor in the subsequent fiscal and political crisis of that state.

The policy implications, we believe, are not very different from those associated with an analysis of the speculative mania of the late 1990s itself.   It was not a good idea for the authorities to look the other way, encouraging the notion that a "new paradigm" had arrived that would, on account of information technology alone, transform everyone's lives. It would have been better had they encouraged a wider distribution of economic gains, and a broader geographic distribution of income gains. It is possible that, had they done so, both the local and the national consequences of the ensuing slowdown might have been less severe.

Figure 1: The Between County Theil Index 1969 - 2001

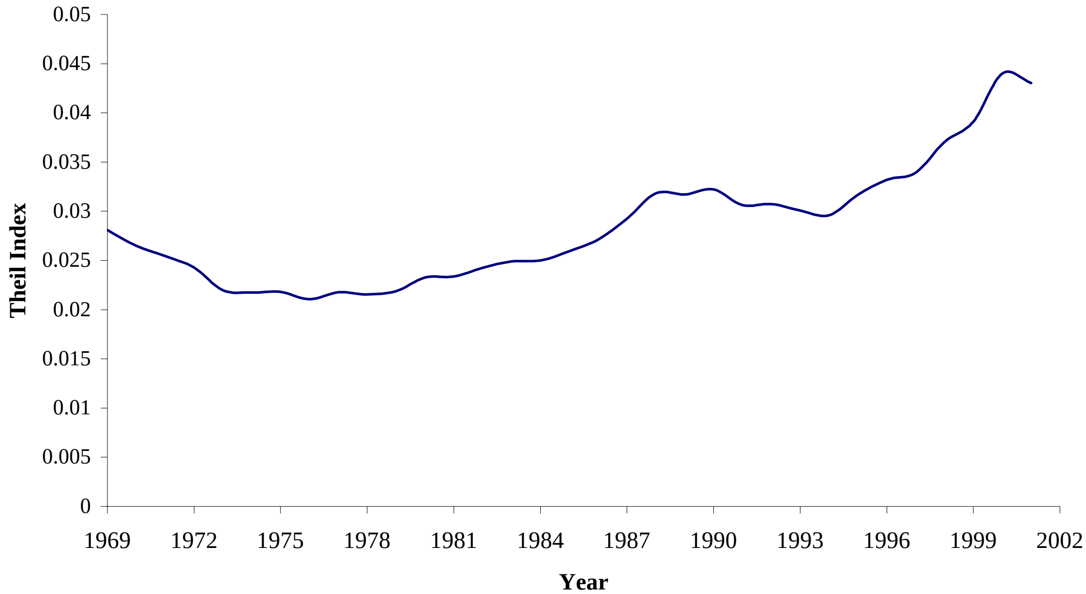


Figure 2: County Theil Elements for 2000 (Black for positive, white for negative)

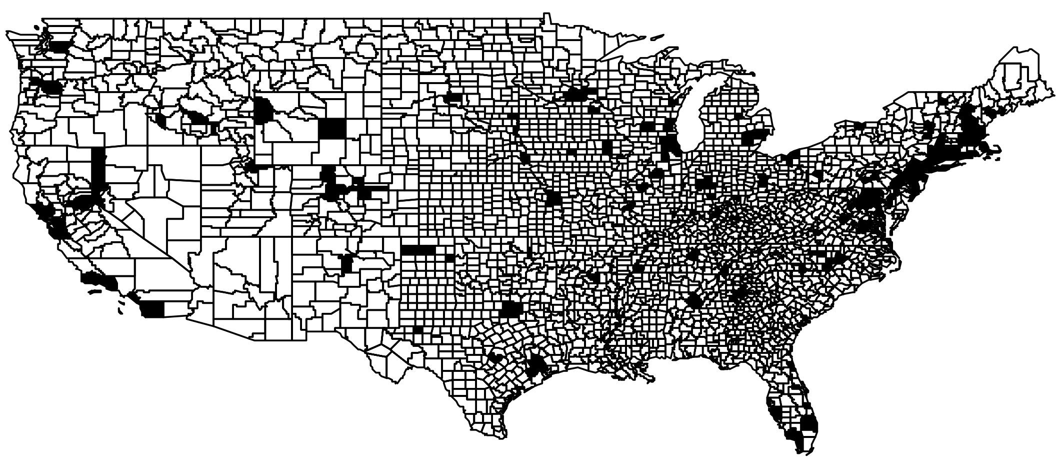
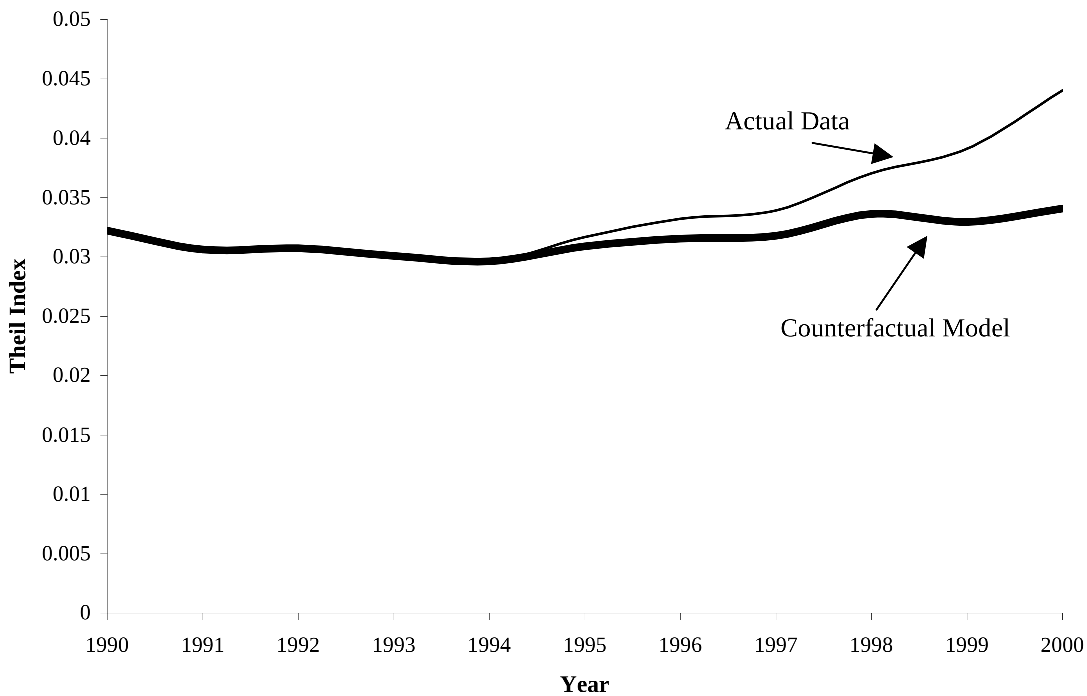


Figure 3: Nasdaq Composite Monthly Close

Figure 4: Between-County Theil Index 1990 - 2000 with Counterfactual Model



[1] This data is readily available at http://www.bea.gov/bea/regional/reis/ .

[2] Unfortunately, the definition of "county" is not as simple as one might imagine. The Federal Information Processing Standards Publication 6-4 gives the precise definition of "county":

"The term "counties" refers to the "first-order subdivisions" of each State and statistically equivalent entity, regardless of the local terminology (county, parish, borough, etc.). First-order subdivisions of the States include the parishes of Louisiana; the boroughs and census areas of Alaska; the independent cities of Maryland, Missouri, Nevada, and Virginia; and the portion of Yellowstone National Park in Montana."

http://www.itl.nist.gov/fipspubs/fip6-4.htm

In addition the states of Arizona, New Mexico, and Wisconsin have either consolidated or created new counties since 1969.

[3] http://www.fri.fujitsu.com/open_knlg/review/rev061/08forlam-english.pdf

[4] Included companies: Adaptec Inc, ADC Telecommunications Inc, Adobe Systems Incorporated, Advanced Micro Devices Inc, Altera Corporation, Amazon.com Inc, American Power Conversion Corporation, Ameritrade Holding Corporation, Analog Devices Inc, AOL Time Warner Inc, Apple Computer Inc, Applied Materials Inc, AT&T Corp, Atmel Corporation, BellSouth Corporation, Broadcom Corporation, Cadence Design Systems Inc, CIENA Corp, Cisco Systems Inc, Citrix Systems Inc, CMGI Inc, CNET Networks Inc, Computer Associates International Inc, Compuware Corporation, Conexant Systems Inc, Cox Communications Inc, Cypress Semiconductor Corporation, Dell Inc, DoubleClick Inc, E*TRADE Group Inc, eBay Inc, Electronic Data Systems Corp, EMC Corporation, First Data Corporation, Gateway Inc, Hewlett-Packard Co, Ingram Micro Inc, Intel Corporation, InterActiveCorp, International Business Machines Corporation, Intuit Inc, JDS Uniphase Corporation, KLA-Tencor Corporation, Knight Trading Group Inc, Level 3 Communications Inc, Lexmark International Inc, LM Ericsson Telephone Company, LSI Logic Corporation, Lucent Technologies Inc, Maxim Integrated Products Inc, Micron Technology Inc, Microsoft Corporation, Motorola Inc, National Semiconductor Corp, Networks Associates Inc, Nextel Communications Inc, Nokia Corporation, Nortel Networks Corporation, Novell Inc, Oracle Corporation, Parametric Technology Corp, PeopleSoft Inc, PMC-Sierra Inc, priceline.com Incorporated, QUALCOMM Incorporated, Qwest Communications International Inc, RealNetworks Inc, SBC Communications Inc, Siebel Systems Inc, Sprint FON Group, Sun Microsystems Inc, Tellabs Inc, Teradyne Inc, Terra Lycos S.A, Texas Instruments Inc, Unisys Corp, VeriSign Inc, VERITAS Software Corporation, Verizon Communications Inc, Vitesse Semiconductor Corp, Walt Disney Company, Xerox Corp, Xilinx Inc, Yahoo! Inc.

[5] Fifty-seven of the eighty CNET companies are headquartered in the fifty counties that had the largest increases in their Theil elements from 1994 to 2000.

[6] Only three of the eighty CNET companies are headquartered in the fifty counties that had the largest decreases in their Theil elements from 1994 to 2000.