

#21 The Baby Boom Chart Book 1991

#22 Apocalypse Now? (NOT!)

#23 The End Of The Cold War Is Bullish

#24 Hard Or Soft Landing?

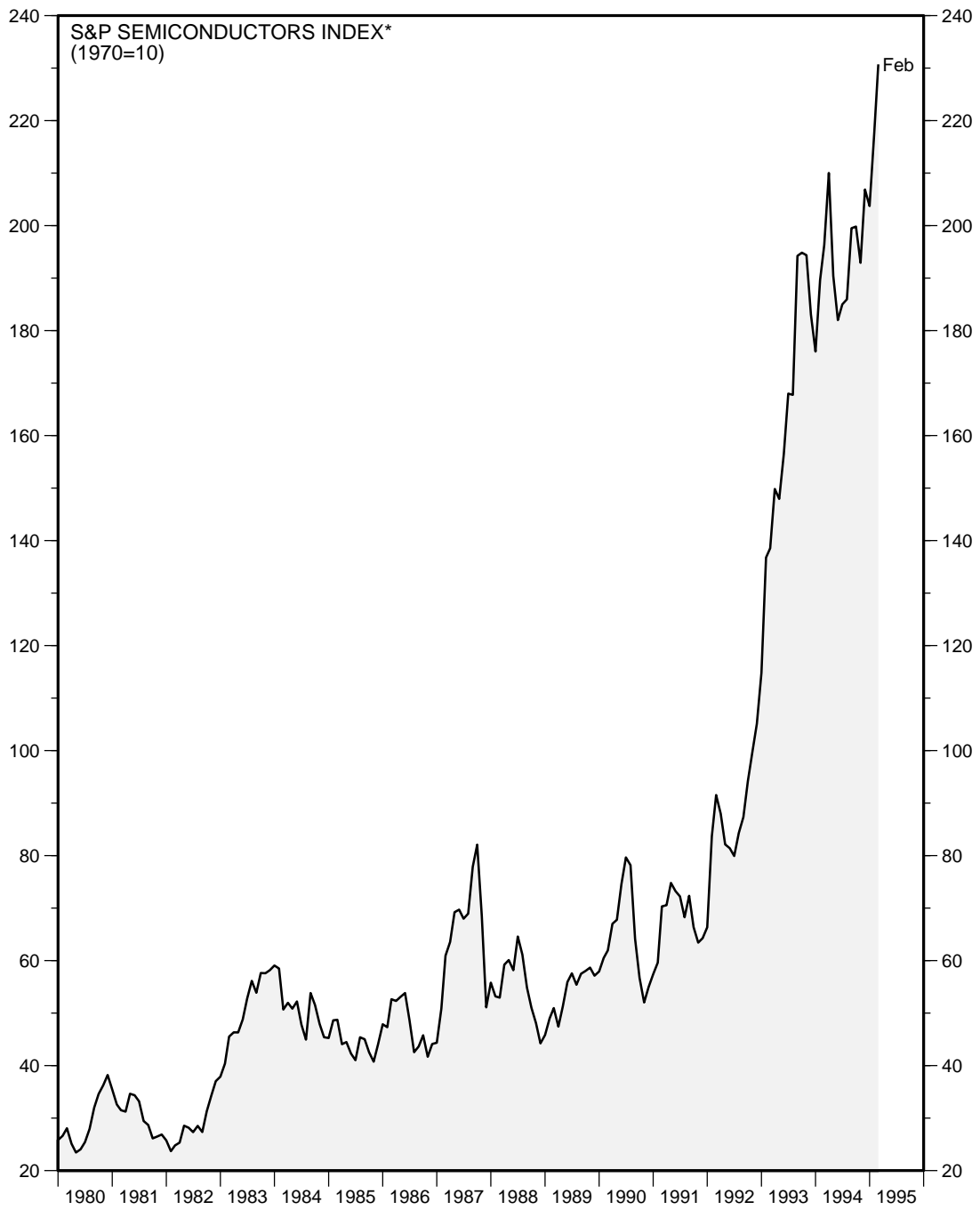
Topical Study #25

THE HIGH-TECH REVOLUTION IN THE US of @

March 20, 1995



Dr. Edward Yardeni
Chief Economist



* Currently includes Advanced Micro Devices, Intel, Motorola, National Semiconductor, and Texas Instruments.

THE HIGH-TECH REVOLUTION IN THE US of @

I. New Wave vs. Old Cycle

I first started to write about the High-Tech Revolution in the January 7, 1993 issue of my *Weekly Economic Analysis*. I wrote that “the US economy is on the threshold of a major Technological Revolution, led by the personal computer. This revolution will continue to boost productivity well above the anemic growth of the 1970s and 1980s.”

I am more convinced than ever that our economy is rapidly evolving in a very positive direction. Real incomes will grow at a faster pace along with productivity. Bearish problems like the federal and trade deficits will be overshadowed by the bullish consequences of the High-Tech Revolution.

I am especially bullish on the stock prices of high-tech companies (Exhibits 1, 2, and 3). During February of this year, they accounted for 11% of the market capitalization of the S&P 500, up from 7% during 1992. As high tech becomes a bigger and bigger share of the economy, this capitalization ratio should at least match, and will probably surpass, the 1984 high of 17% of the S&P 500.

The standard tools of macroeconomic analysis, particularly business cycle indicators, may no longer accurately reflect the true nature of our economy. Similarly, forecasts based solely on the business cycle model may also miss the mark. The secular trends unleashed by the High-Tech Revolution could overwhelm the cyclical pattern of the low-tech economy. This is not to say that the business cycle is dead. However, it may no longer dominate the course of economic growth as it did in the past.

This optimistic future would be ironic, of course, because there has been so much pessimism about the long-term prospects for the US economy in recent years, much as there was about Great Britain at the turn of the eighteenth century. During the final three decades of the 1700s, it was said that Britain was in decline. The country had huge debts to foreign investors. There was much concern about foreign competition, especially from the Americans after they declared their independence from the empire. The gloom was ironic, because Britain was on the verge of the great Industrial Revolution, which dramatically increased the power and wealth of Britain during the 1800s.

One of the main reasons that Adam Smith wrote *The Wealth of Nations*, which was published in 1776, was to counter the intellectual pessimism that was so popular at the end of the eighteenth century. He predicted that if Britain abandoned mercantilism and embraced laissez-faire policies, the country would prosper. He was right. (See my Topical Study #19, *The Triumph of Adam Smith*, July 17, 1990.) I believe the pessimists will be wrong again as the High-Tech Revolution moves ahead.

II. Speed

The High-Tech Revolution isn't a fantasy. It has already begun:

- Spending on high-tech capital equipment soared to \$270 billion during the fourth quarter of 1994, up 88% over the past three years (Exhibit 4). Such outlays currently account for nearly 50% of expenditures on producers' durable equipment, up from 22% in 1980 (Exhibit 5). None of these figures include spending on software programming, which is expensed rather than capitalized. In my opinion, it should be capitalized. I estimate that 60% or more of capital equipment spending is high tech if software is treated as an integral component of the hardware.
- High-tech capital equipment spending has a very strong uptrend, with no significant cyclical pattern. Low-tech spending is very cyclical, with a modest long-term uptrend. It tends to fluctuate coincidentally with the business cycle as measured by the capacity utilization rate (Exhibits 6 and 7).
- The uptrend in high-tech equipment spending has been dominated by computers. Computers now account for 57% of high-tech capital equipment spending, up from only 15% during 1980 (Exhibits 8 and 9).
- Industrial output of computers is up 106% over the past three years, or 2.9% per month on average. Computers have dominated production of business equipment, which is up 29% over the past three years, or almost three times faster than industrial production of consumer goods, including cars (Exhibits 10 and 11)!

The dramatic upturn in computer purchases over the past three years was triggered by a significant increase in the processing speed of computer hardware as prices plummeted. At the same time, computer software became much more powerful and easier to use. Table 1 appeared in the February 20 issue of *Business Week*. In 1983, Intel first shipped the 286 microprocessor in volume with an initial speed of 1 million instructions per second (MIPs). The 386 chip was shipped in volume during 1986. It was five times faster than the 286.

The 486 was four times faster than the 386 and twenty times faster than the 286. It launched the high-tech revolution once Intel started volume shipments in the early 1990s. According to the table, Intel has sold 75 million 486 chips. Compaq Computer Corporation started a price war in 1992, which made the powerful 486 machine very affordable. Also, in April 1992, Microsoft introduced version 3.1 of Windows. It was much easier to use than the MS-DOS operating system and led to a dramatic increase in Windows-based software applications.

The Pentium chip was introduced in 1993 and bulk-shipped the following year. It is rated at 100 MIPs. The P6 is scheduled to be introduced later this year. It is supposed to operate at a blazing speed of 250 MIPs. Before the end of the decade, the P7 could deliver a blistering 500 million instructions per second.

Table 1: Chronology of Intel's microprocessors

	286	386	486	Pentium	P6	P7
Start of design work	1978	1982	1986	1989	1990	1993
Formal introduction	Feb 1982	Oct 1985	Apr 1989	Mar 1993	Q3 1995	1997/98
Volume shipments	1983	1986	1990	1994	1996	1998/99
Number of transistors	130,000	275,000	1.2 million	3.1 million	5.5 million	10+ million
Initial speed in MIPs*	1	5	20	100	250**	500**
Peak sales year	1989	1992	1995**	1997**	1999**	2002**
Installed units	9.7 million	44.2 million	75 million	4.5 million	none	none

* Millions of instructions per second **Estimated
Source: *Business Week*, February 20, 1995

III. A Deflationary Product Cycle

One of the most unusual, and certainly most unique, attributes of the computer industry is that prices fall even as processing power soars and demand exceeds supply. Table 2 on the next page shows the dramatic increase in MIPs that can be purchased for \$100 since 1978. From 1982 through 1995, MIPs per \$100 rose from 1 to an estimated 30.

The computer industry is clearly booming. The capacity utilization rate recently soared to 91.4%, up sharply from 68.4% three years ago. The rebound in utilization occurred despite the fastest growth in capacity of any manufacturing industry (Exhibits 12 and 13).

Table 2: Affordability of chip power

	What \$100 Bought In MIPs*
1978	0.5
1982	1.0
1985	2.0
1989	2.5
1992	9.0
1993	15.0
1994	20.0 **
1995	30.0 **

* Millions of instruction per second **Estimated
Source: Intel

From the first quarter of 1980 through the fourth quarter of last year, the computer price deflator declined 76%. Over this same period, the GDP price deflator rose 83%. The relative price of computers, i.e., the ratio of the computer deflator to the GDP deflator, plunged 87% since 1980 (Exhibits 14 and 15). The extraordinary decline in both the *absolute* and *relative* prices of computers has stimulated a great deal of buying in this sector.

In high-tech markets, falling prices are the reason why demand exceeds supply. But why do prices fall so rapidly in the face of booming demand? As soon as a computer chip is introduced, manufacturers are already developing the next generation. Innovators of generation “n” chips are forced to create “n+1” chips. If they don’t, the competition soon will. *This situation means that the most successful producers of technology must cannibalize their own products to remain successful.*

The cost of high-tech research and development is so great these days that high-tech manufacturers must sell as many units as possible of their new products in as short a period of time as possible before the n+1 generation is introduced. That’s why they tend to offer more power at a lower price with the introduction of each new generation.

Also, the introduction of n+1 immediately reduces the demand for the *n*th chip and the *n*th computer. As the price of the old technology falls, it limits the upside of the price of the newest technology.

As a result of these unique trends, the purchasers of high-tech hardware are constantly receiving more bang for their buck. Commerce Department data show that high tech currently accounts for 36% of total producers’ durable equipment spending using nominal prices. But, after adjusting for inflation—or rather deflation, high tech accounts for 49% of real producers’ durable equipment outlays (Exhibit 5). In real terms, high tech now accounts for about 38% of total capital spending, up from 14% in 1980, and 5.0% of real GDP, up from 1.7% in 1980 (Exhibits 16 and 17). Computers currently account for 22% of real capital spending and 28% of real producers’ durable equipment outlays and 57%

of high-tech capital equipment spending (Exhibit 9). I believe that high tech will become an even more significant sector of the economy.

IV. The Fourth Dimension

The plunge in the cost of MIPs is probably the most extraordinary deflation in the history of this planet. In effect, the High-Tech Revolution has created a fourth factor of production—namely, Information. The original three factors are Land, Labor, and Capital.

Factors of production are substitutable for each other. Until recently, Information was hard to substitute for Land, Labor, or Capital. It was very expensive to gather, process, and manage. There were usually long lags between the creation of the raw data and its conversion into useful information. The lags made the information less useful once it was available. It was old news by the time it was available to decision makers.

With the High-Tech Revolution, enormous quantities of information can be gathered, processed, and managed on a “real-time” basis at lower and lower costs. The price of information is deflating. As it gets cheaper and cheaper, it also becomes more substitutable for the other factors of production.

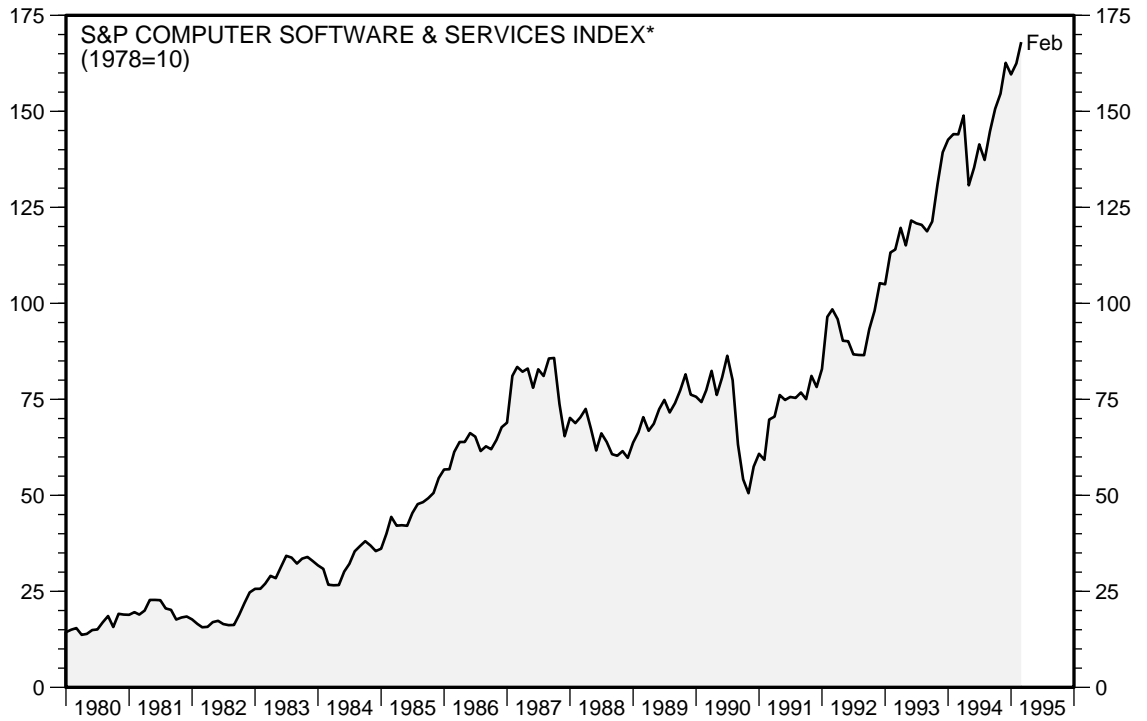
Increasingly, real-time information is replacing labor and capital in the production process. For example, insurance companies can eliminate warehouses of archived files and the associated support staff with scanners that can transfer information to optical disks. The automakers have slashed their inventories with real-time information systems that can automatically place orders with vendors, schedule just-in-time deliveries, and monitor the transportation progress of the orders. As a result, inventories-on-the-shelves can be replaced with “inventories-on-wheels.” Information replaces working capital.

V. “Beam Me Up, Scotty”

In recent speeches, Bill Gates, the Microsoft mogul, suggested that once Intel introduces the P6 and then the P7 microprocessors, he’ll give us software that will do everything except beam us up into the Starship Enterprise. Last year, we all discovered that the information highway already exists in the Internet. Already, a company has developed software for sending voice messages over this network. It won’t be long before we’ll be able to have phone conversations and video conferences over the global Internet system. The cost will be minimal and the impact on running a company will be enormously profitable and bullish for stock prices.

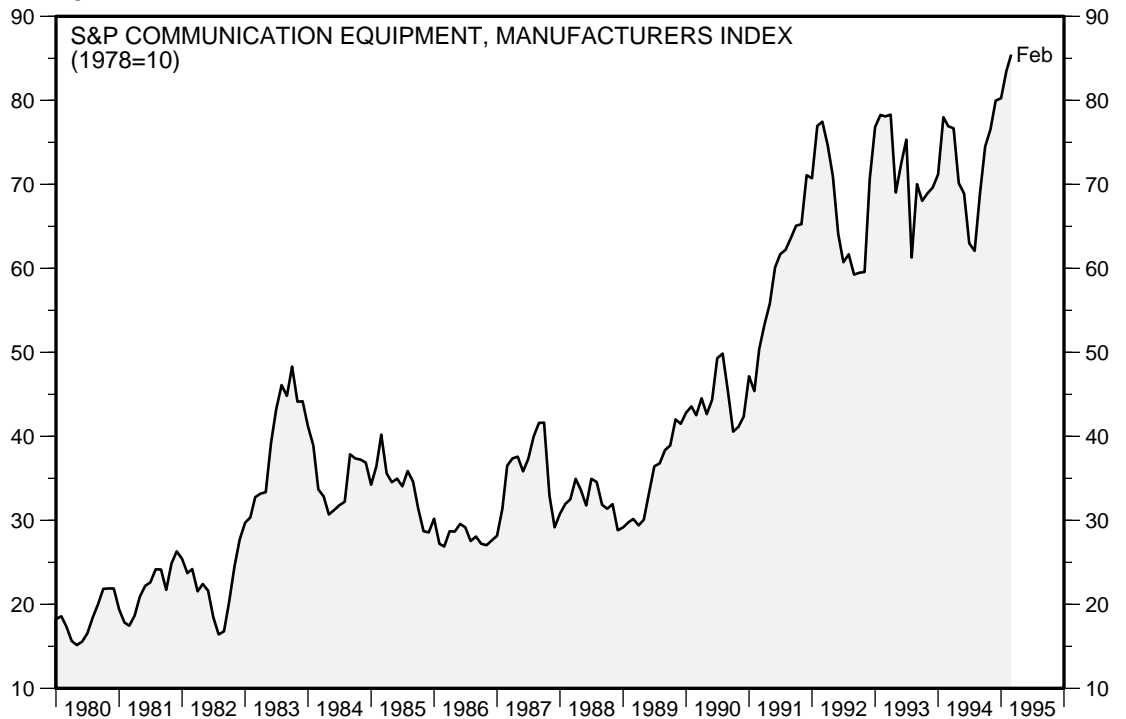
The explosive growth in the number of Internet users is transforming our country into the US of @. All Internet addresses include the @ sign. You can reach me at 70672.1560@Compuserve.com.

#2



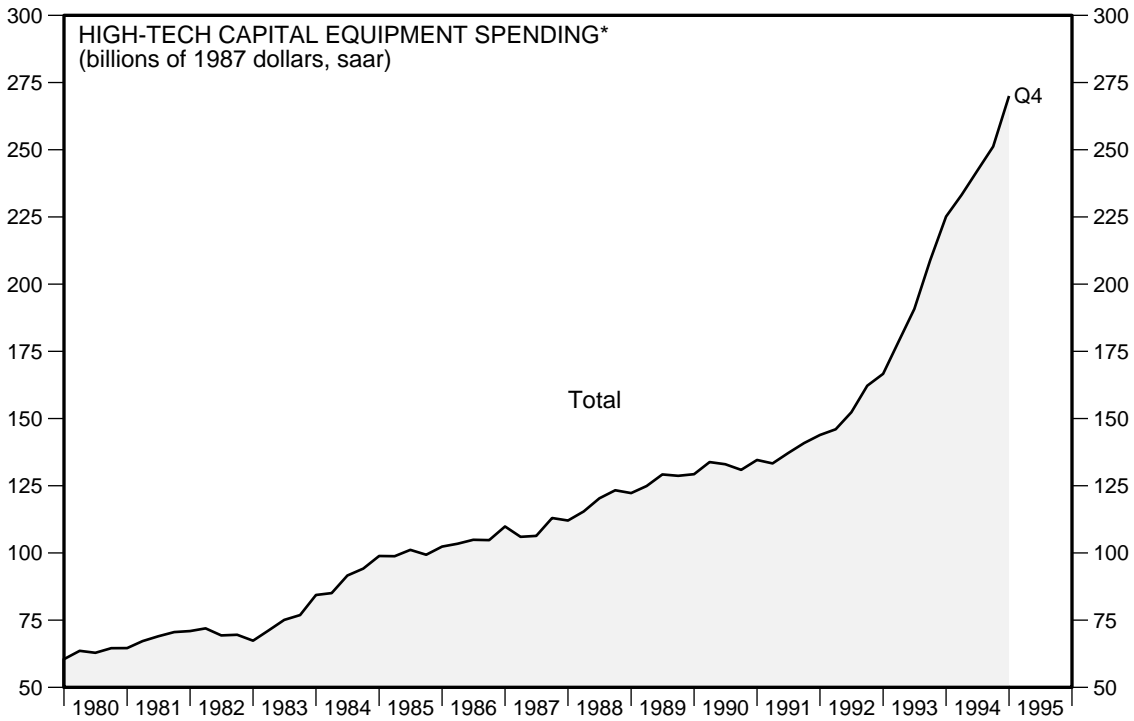
* Currently includes Autodesk, Automatic Data Processing, Ceridian, Computer Associates Int'l, Computer Sciences, Lotus Development, Novell, Oracle Systems and Shared Medical Systems.

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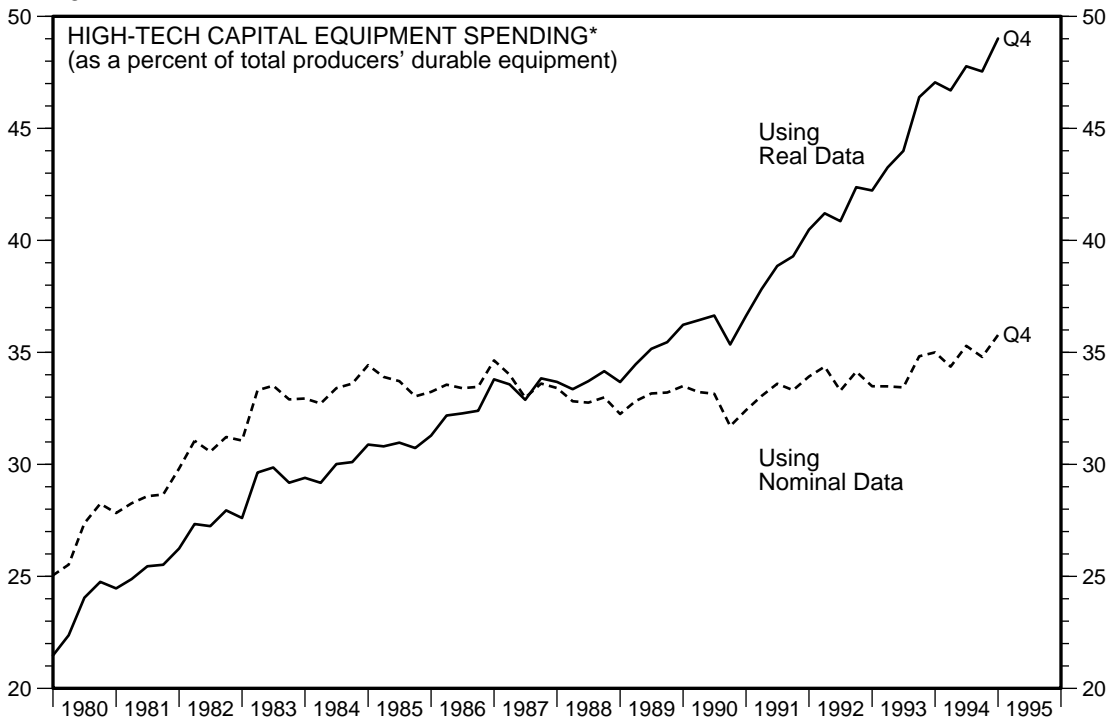
* Currently includes Andrew, DSC Communications, M/A Com, Northern Telecom, and Scientific-Atlanta.

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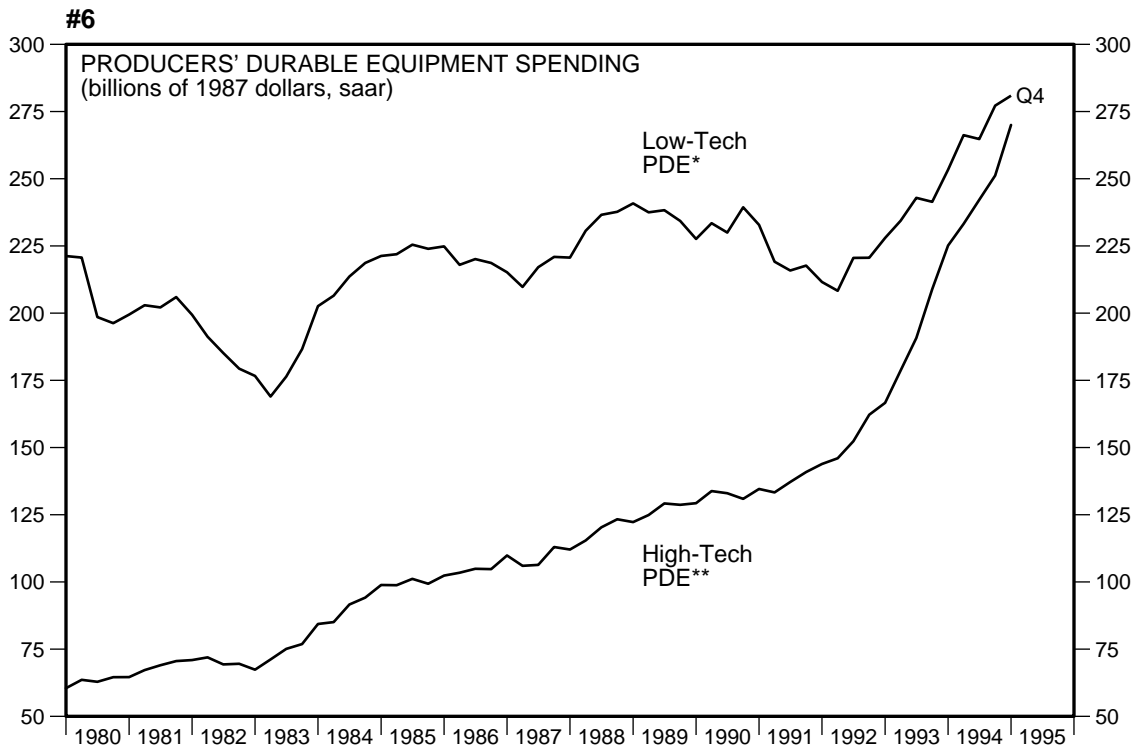


* Producers' durable equipment spending on office and store machinery, communication equipment, photographic equipment, and scientific and engineering instruments.

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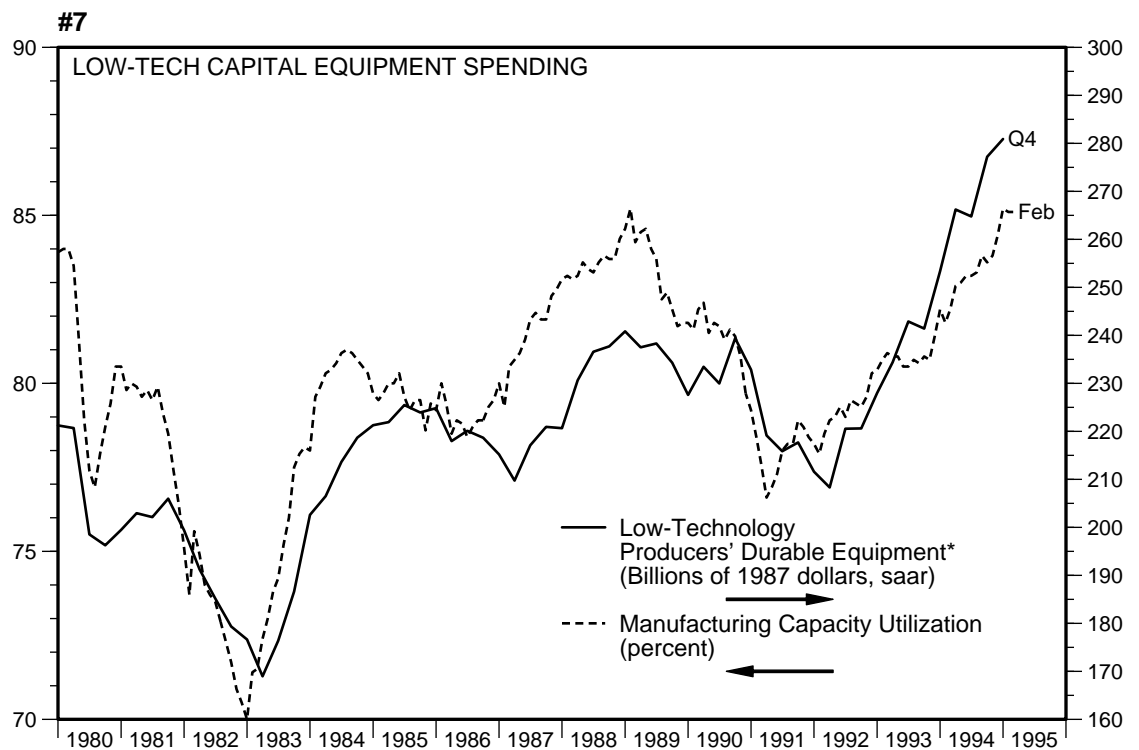


* Producers' durable equipment spending on office and store machinery, communication equipment, photographic equipment, and scientific and engineering instruments.



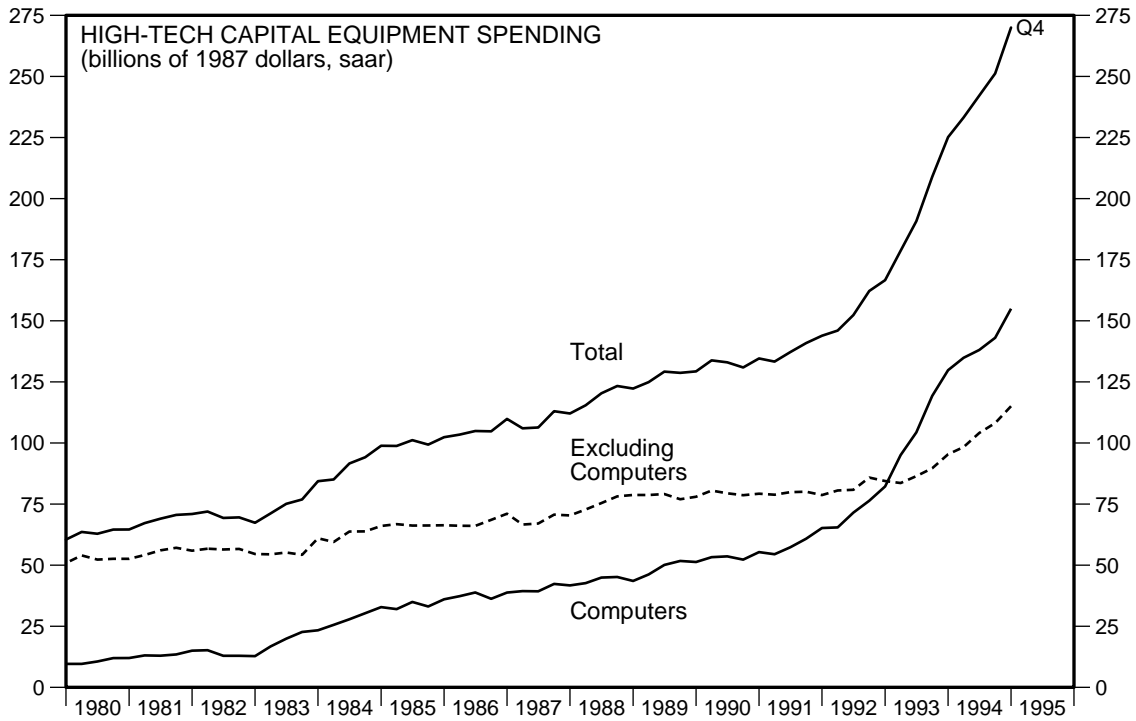
* Including heavy industrial equipment, transportation equipment, and other equipment.

** Producers' durable equipment spending on office and store machinery, communication equipment, photographic equipment, and scientific and engineering instruments.

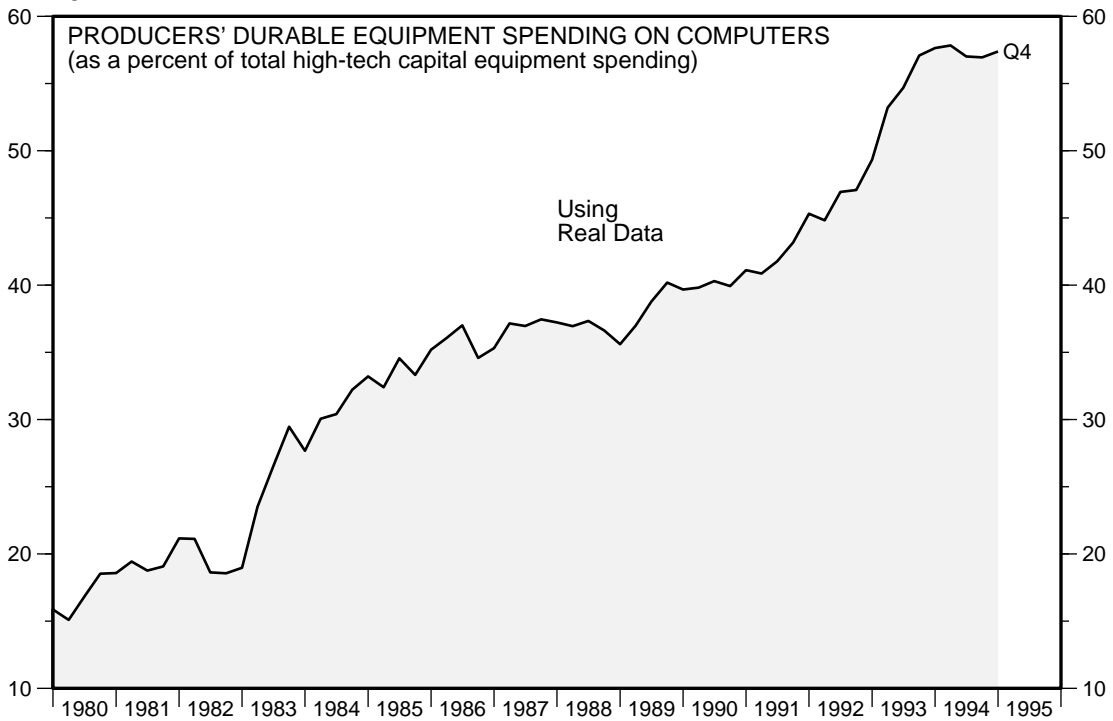


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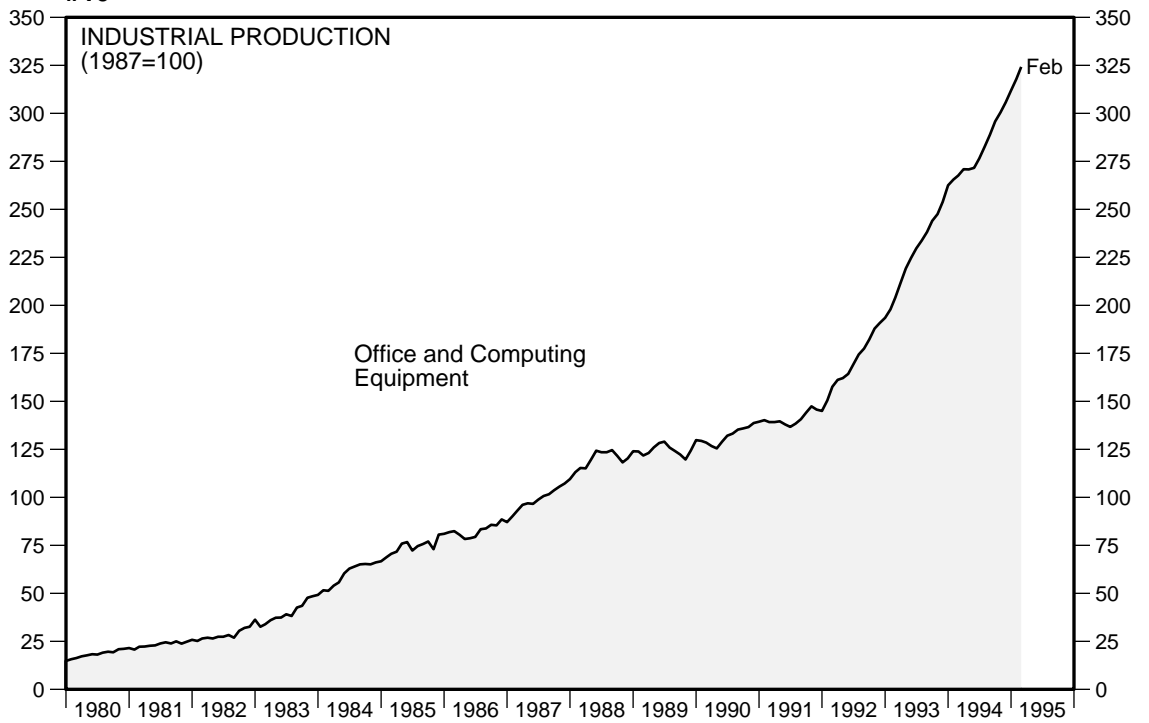
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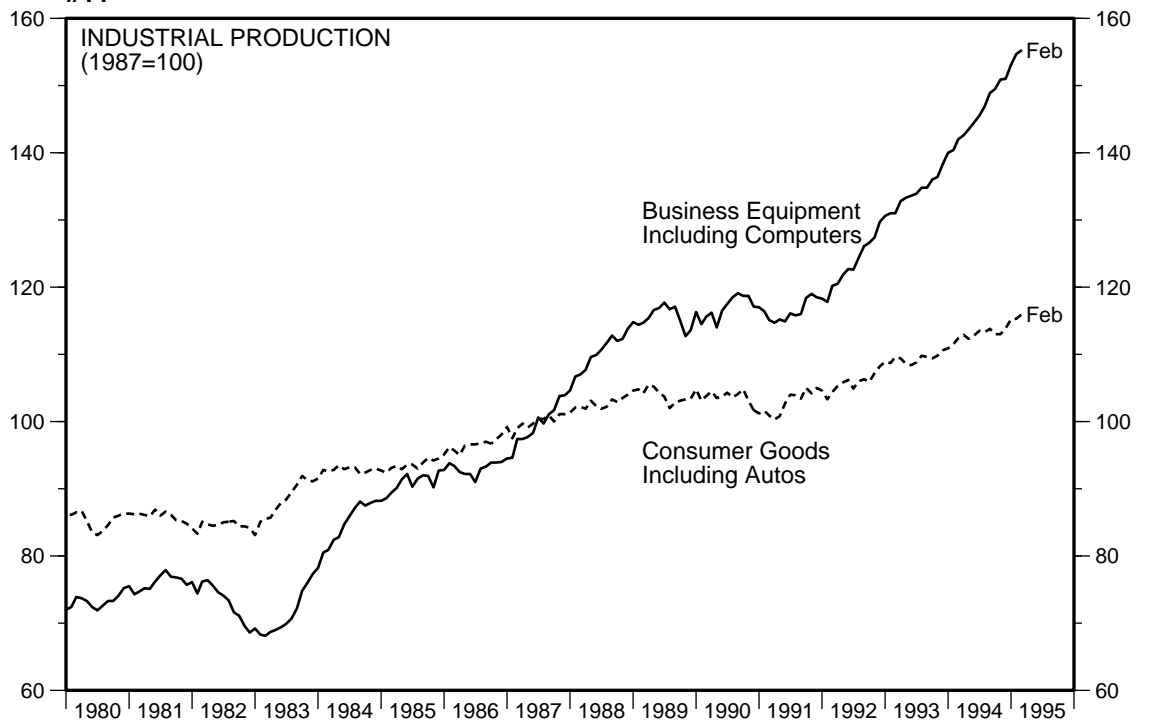
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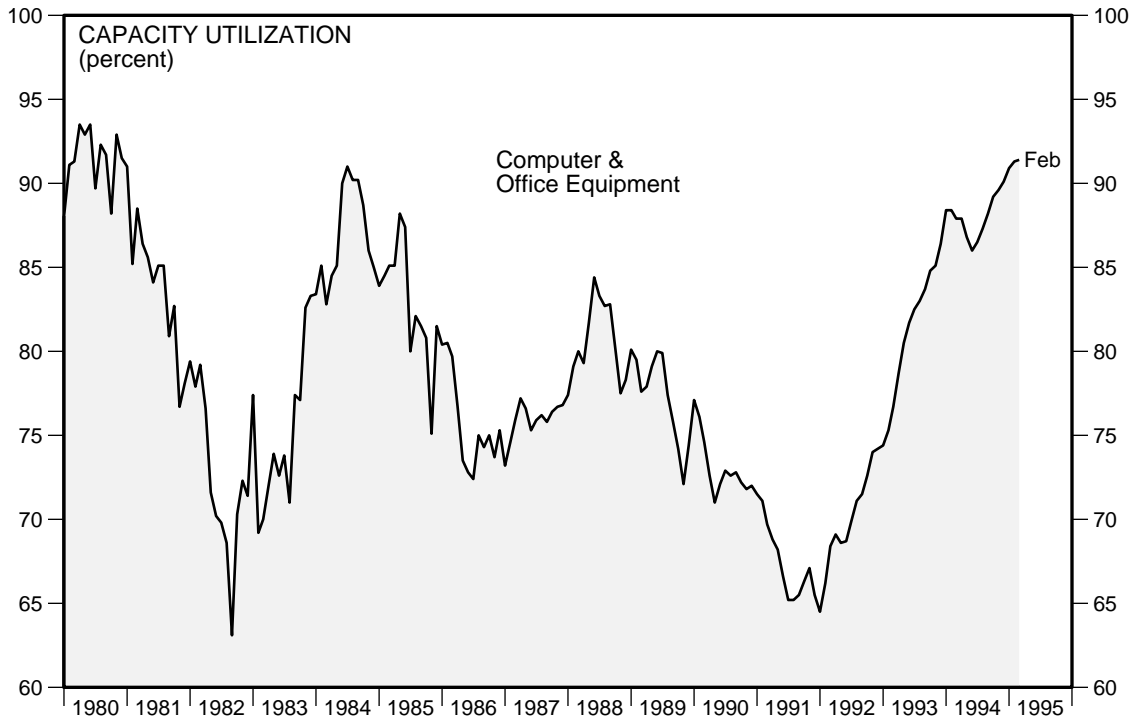
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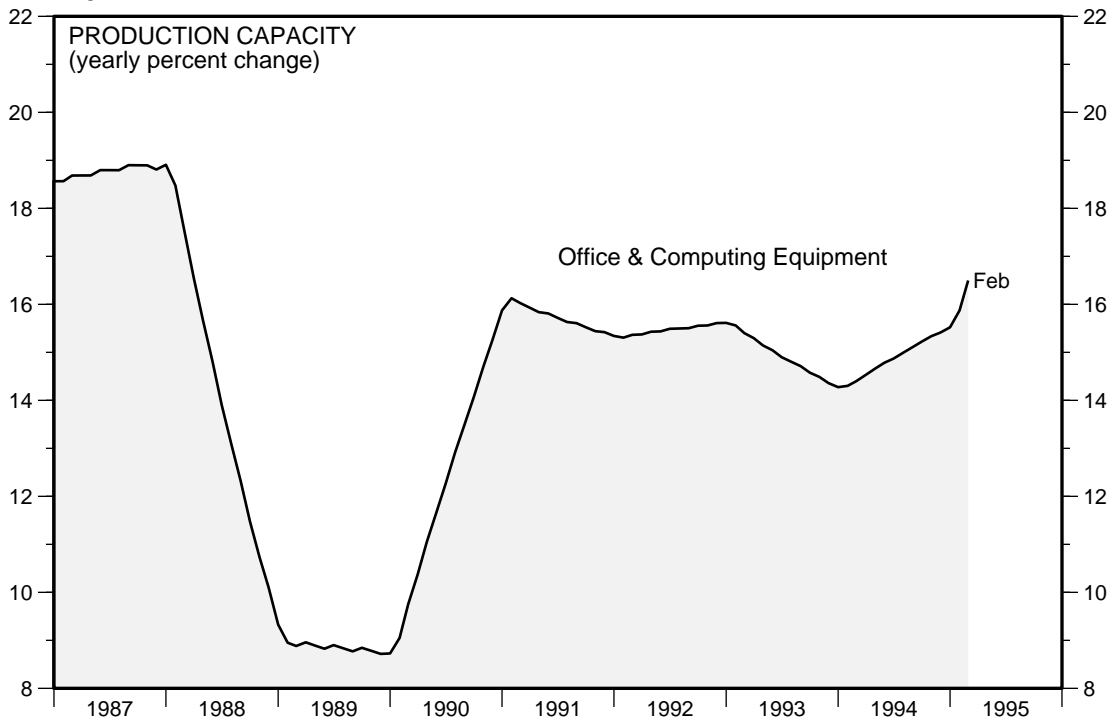
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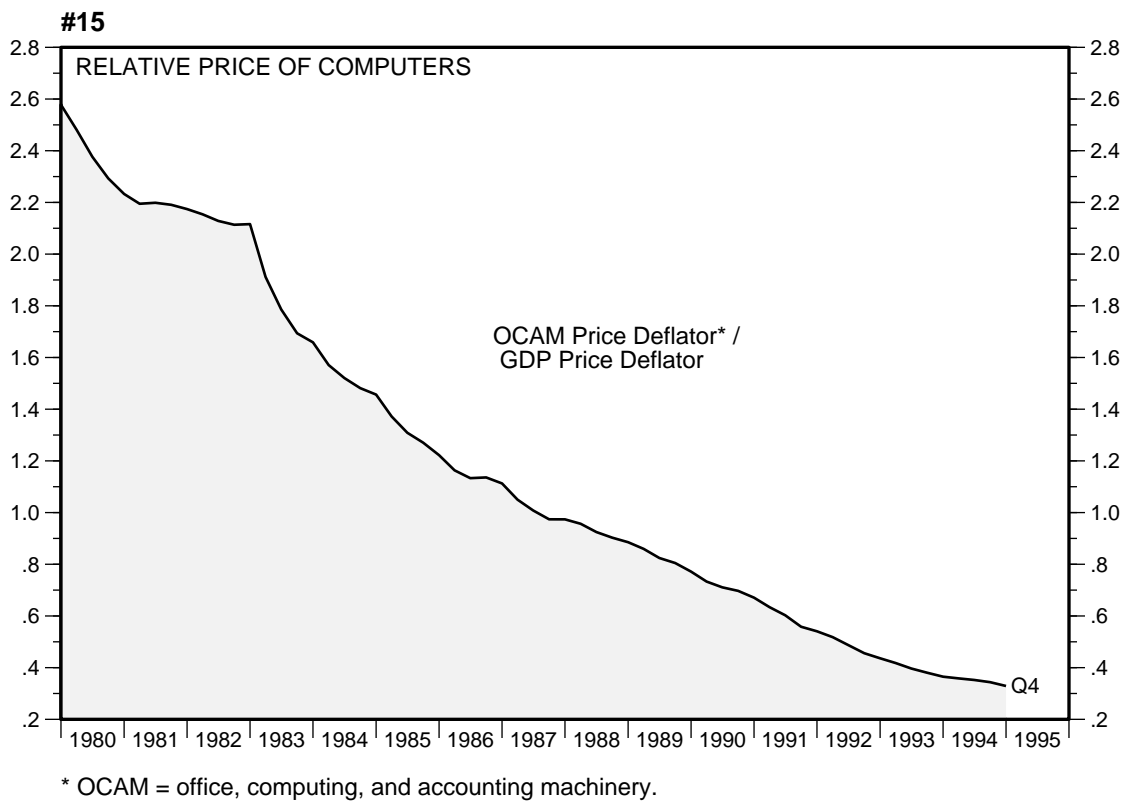
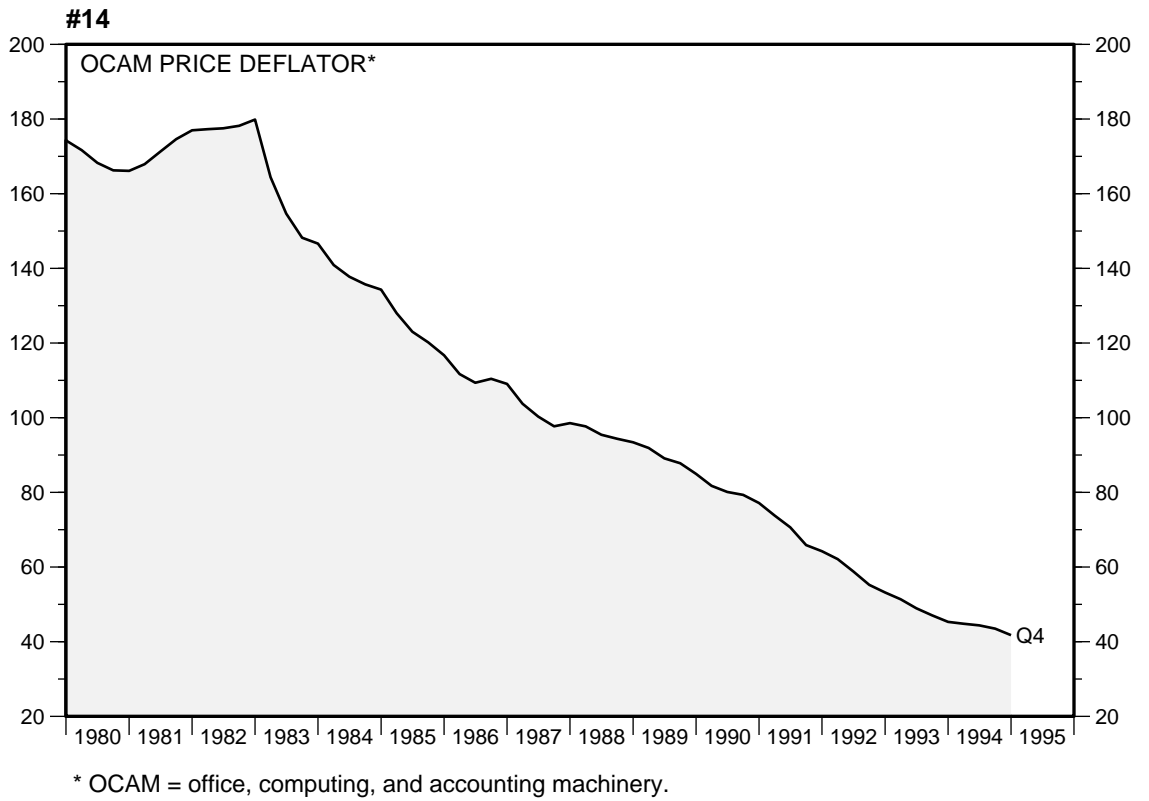


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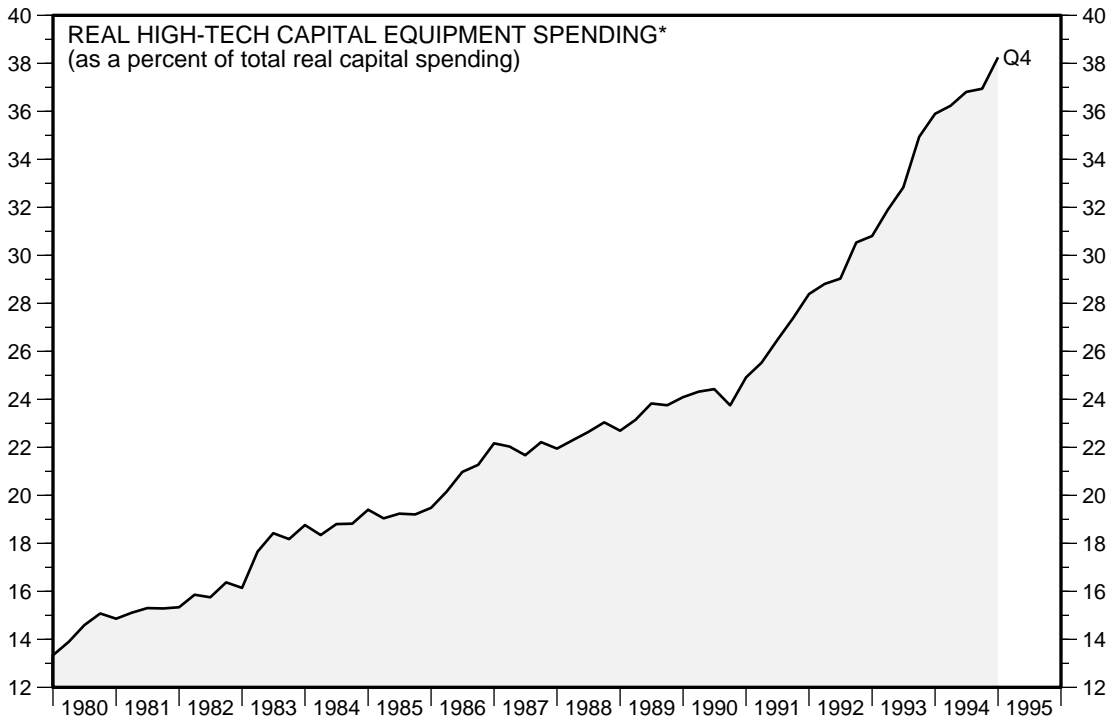


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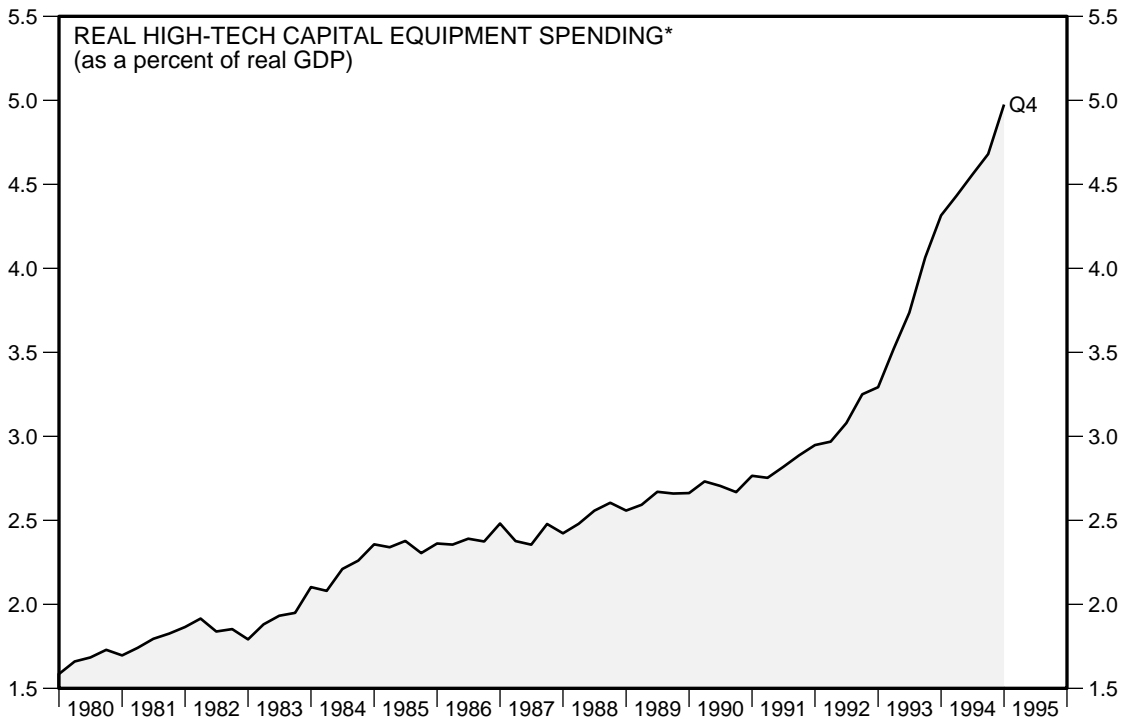


#16



* Producers' durable equipment spending on office and store machinery, communication equipment, photographic equipment, and scientific and engineering instruments.

#17



* Producers' durable equipment spending on office and store machinery, communication equipment, photographic equipment, and scientific and engineering instruments.

TOPICAL STUDIES

- #1 Dr. Edward Yardeni, *Exports Should Weaken US Recovery*, March 22, 1983 *
- #2 Dr. Edward Yardeni, *The Ten Pillars Of Faith*, April 6, 1984 *
- #3 Deborah Johnson, *Behind The Corporate Borrowing Binge*, June 13, 1984 *
- #4 Dr. Edward Yardeni, *Why Has The Leading Index Of Inflation Failed So Badly?*, October 24, 1984 *
- #5 Dr. Edward Yardeni, *The Case For Lower Oil Prices*, December 12, 1984 *
- #6 Dr. Edward Yardeni, *The True Story Behind The Mighty Dollar*, January 9, 1985 *
- #7 Dr. Edward Yardeni, *Plenty Of Cash Around To Fuel Additional Stock And Bond Gains*, January 30, 1985 *
- #8 Dr. Edward Yardeni, *No Shortage Of Gluts*, July 10, 1985 *
- #9 Dr. Edward Yardeni, *The Protectionist Road To Depression*, September 9, 1985
- #10 Dr. Edward Yardeni, *The US Becomes The World's Largest Debtor, So What?*, July 14, 1987
- #11 Dr. Edward Yardeni and Deborah Johnson, *The Restructuring Of Corporate America Is Bullish*, December 9, 1987
- #12 Dr. Edward Yardeni, *How The Baby Boomers Are Changing The Economy*, April 6, 1988
- #13 Dr. Edward Yardeni, *The Coming Shortage Of Bonds*, June 20, 1988
- #14 Dr. Edward Yardeni, *Could Real Estate Prices Fall? And What If They Do?*, August 24, 1988
- #15 Dr. Edward Yardeni and David Moss, *The New Wave Manifesto*, October 5, 1988
- #16 Dr. Edward Yardeni with Amalia Quintana, *The Baby Boom Chart Book*, January 25, 1989
- #17 Dr. Edward Yardeni, *The Triumph Of Capitalism*, August 1, 1989
- #18 Dr. Edward Yardeni and Deborah Johnson, *Dow 5000*, May 9, 1990
- #19 Dr. Edward Yardeni and David Moss, *The Triumph Of Adam Smith*, July 17, 1990
- #20 Dr. Edward Yardeni, *The Collapse Of Communism Is Bullish*, September 4, 1991
- #21 Dr. Edward Yardeni with Amalia Quintana, *The Baby Boom Chart Book 1991*, October 9, 1991
- #22 Dr. Edward Yardeni, *Apocalypse Now! (NOT!)*, May 8, 1992
- #23 Dr. Edward Yardeni, *The End Of The Cold War Is Bullish*, September 10, 1993
- #24 Dr. Edward Yardeni, *Hard Or Soft Landing?*, February 6, 1995

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