Chapter 6

# Advanced TV Markets and Market Uncertainties

## INTRODUCTION

The future growth and ultimate size of the various advanced TV and related markets is unknown. This may be unimportant for ATV-related R&D. The mere expectation of a large market seems to be inducement enough for many manufacturers to push the state-of-the-art in ATV technologies (ch. 5). In contrast, the growth rate and size of these various markets directly determines the economies of scale in production of the component technologies (e.g., displays, semiconductors, and data storage) as well as in the manufacturing processes for sophisticated electronic systems.

Development of HDTV markets depends on many complicated and unpredictable factors.[1] How much consumers will be willing to pay for HDTV-quality pictures is a matter of speculation. Consumers may prefer to spend their disposable income on a wider variety of programming choices, other entertainment systems, lower resolution interactive video systems, or more basic staples or amenities. For those consumers that are interested in purchasing HDTVS, there remain a series of ''chicken-and-egg' problems to overcome:

- Consumers are unlikely to buy receivers until a wide variety of HDTV broadcasting is available; but broadcasters hesitate to offer HDTV programs until there are enough viewers to make it worthwhile.
- Consumers are unlikely to buy receivers until the cost comes down to acceptable levels; but manufacturers can't get the cost of receivers down until millions of consumers are purchasing HDTVS and enable large-scale mass production and streamlined manufacturing processes.

In contrast to the U.S. market-driven approach, the Japanese are actively trying to overcome these problems in the interest of developing their domestic market. This approach carries both risks and potential benefits: they may fail at a large scale but their chances of success are improved.

The uncertainties in the details of how the HDTV and other ATV markets will develop should not obscure important underlying trends in the technology. No matter what form video entertainment systems take in the future, they will increasingly use digital electronics for higher performance at reduced costs. For example, digital microprocessors are already common in television tuners and IDTVS have recently come on the market.

The rate at which fiber-optics is extended to the home and how it is connected may be similarly debated, but not its eventual widespread use. Improved economics and superior performance of fiber systems make this transition inevitable. The merging of digital video entertainent systems and fiber might then make a host of new information services possible. The question is how to provide a flexible framework for linking fiber to the home and bringing digital video systems into the home with the least overall disruption to the national telecommunications infrastructure—all at an affordable price.

A few of the possible market scenarios will first be examined qualitatively; then market projections by several leading groups will be discussed. The trend in technology towards digital/fiber systems will be reviewed. Finally, some of the market conflicts generated by the coming introduction of ATV services will be examined.

## SCENARIOS FOR MARKET DEVELOPMENT

No one knows how the ATV market will develop. HDTV might prove irresistible to consumers and the market may grow rapidly, with corresponding economies of scale quickly lowering costs and making HDTV available to most families-perhaps even a second set. The HDTV market might grow more slowly: growing only after much larger and improved display technologies are available; after consumers are sensitized to the value of its higher

[1]HDTV is focused on specifically here because it represents a significant cumulative change from today's TV that may Or may nOt be made in roughly one step, depending on the choice of transmission standards.



30-368 - 90 - 4 : QL 3

picture quality; and after quality programming is available.[2] Less advanced versions of ATV such as IDTV or EDTV might prove more than adequate for most consumers, limiting HDTV to a small high-end residential market and to movie theaters, bars, or restaurants. Or perhaps lower resolution interactive video systems will reach a level of performance sufficient to stimulate significant consumer interest and vie with advanced TVs for consumer dollars.

An advanced form of HDTV might become the home information center, providing entertainment, computer, and telecommunications services in a single generalized piece of equipment. Alternatively, and perhaps more likely, these different services will instead continue to be primarily provided by separate, somewhat specialized pieces of equipment. Even in this case, the continuing decline in the cost of computer and advanced telecom systems will allow them into an ever larger fraction of households; while the home ATV continues to primarily provide entertainment.

In the longer term, having an advanced HDTV with the capability of interactivity-the equivalent of a computer, but for video images-might be very attractive to consumers. These systems might allow consumers to create personalized newspapers; browse distant databases; request more in-depth information on a news program; transmit an interesting movie clip to a friend; or even use an electronic yellow pages to see a video clip of the inside of a restaurant they want to try. Alternatively, such services might be provided by a telecom/computer system while the HDTV, again, simply provides entertainment. Or consumers may decide that such interactivity is not worth the cost or effort in either case.

## *Consumer Demand for HDTV*

Little reliable information is available on consumer demand for high-quality video entertainment; the consumer response to higher quality pictures is ambiguous. Many consumers watch TV without the benefit of either rooftop antennas or cable, depending instead on rabbit ears or internal antennas. Many viewers still watch black and white TVs, at least as a second set—some 3.5 million B&W TVs were sold in the United States in 1987.[3] On the other hand, cable TV has now penetrated over half of American households—both for the higher quality of picture it provides, and especially for the increased variety of programs it offers. Further, large screens are popular despite their high cost.[4] The market for 25-inch and larger screens increased from 2.8 million in 1982 to 5.5 million in 1987.[5]

HDTV market research is similarly ambiguous. The few studies performed indicate that when compared to studio quality NTSC on today's relatively small displays, the viewer preference for HDTV is tempered by program content and viewing conditions.[6] For example, when these (18- and 28-inch) displays were viewed from a distance where the additional detail provided by HDTV was lost, then viewers naturally had little preference. But viewed up close, 75 percent of the viewers preferred HDTV. These tests may simply reaffirm that to appreciate HDTV large displays are needed. Sony, for example, believes that a 72-inch diagonal is required to portray the full capability of their 1125/60 system.[7]

It is important to note that the pictures shown in these tests were studio quality. For NTSC, this is a significant improvement over what viewers normally see at home: the quality of NTSC TV is often poor due to transmission degradations.[8] For any new

[2]FCC Advisory Committee on Advanced Television Services, Planning Subcommittee Working Party 7: Audience Research, Report, Feb. 14,1989. This report notes the potential difficulties posed by an audience that becomes more sensitive to flaws after a fixed standard is locked into place.

[3]Electronics Industries Association, *Consumer Electronics Annual Review, 1988* cd., Washington, DC.

[4]Lee McKnight, W. Russell Neuman, Mark Reynolds, Shawn O'Donnell, and Steve Schneider, "The Shape of Things to Come: A Study of Subjective Responses to Aspect Ratio and Screen Size," ATRP-T-87, Massachusetts Institute of Technology Media Lab, May 17, 1989.

[5]Thomson Consumer Electronics, Electronics Industries Association, HDTV Information Packet, 1989. Electronics Industries Association *Consumer Electronics Annual Review, 1988* cd., Washington, DC.

[6]W. Russell Neuman, Suzanne Chambliss Neil, Lee McKnight, and Shawn O'Donnell, "Action Memo," House Subcommittee On Telecommunications and Finance, Feb. 1, 1989; W. Russell Neurnan;"The Mass Audience Looks at HDTV: An Early Experiment," paper presented at National Association of Broadcasters' Annual Convention, Las Vegas, NV, Apr. 11, 1988.

[7]Larry Thorpe, Sony Corp., personal communication, Oct. 12, 1989.

[8]William F. Schreiber, Massachusetts Institute of Technology, "Comments Before the FCC on Advanced Television Systems and Their Impact on the Existing Television Service," Nov. 30, 1988.

standard, its susceptibility to transmission degradations are a key consideration (ch. 4).

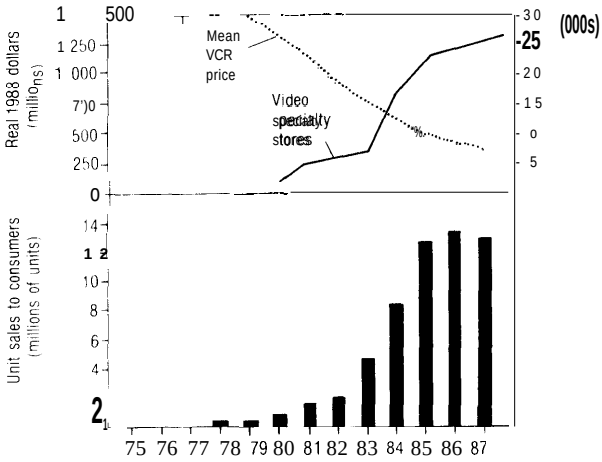
Consumer demand for HDTV receivers will depend on the cost of the set and the availability of program material to view. In turn, receiver costs and program availability will be determined by the size of the market. These factors delayed the takeoff of the color TV market by some 6 or 7 years, from roughly 1955 to the early 1960s. Only the perseverance of RCA, led by David Sarnoff, and the investment of about $3 billion (1988 dollars) kept color TV alive until the necessary critical mass of color programming became available and enabled the market to grow. Similarly, VCRs took off when rental stores for tapes became common (figure 6-1 ).[9]

The response of broadcasters to market demand for color programming in the early 1960s was less ambiguous. Broadcaster costs are roughly constant. A small change in market share (or ratings) then has a significant impact on profit margins. Therefore, broadcasters must compete vigorously for every possible market advantage. Between 1963 and 1966 the share of prime-time hours offered in color went from 20 to 100 percent, even though less than 10 percent of all households had a color TV (figure 6-2). Small changes in market share had enormous leverage over the broadcasters.

### *Consumer Demand for Interactive Video*

Similarly, little reliable information is available on consumer demand for interactive video. Computers, rather than HDTVS, could be the platform for interactive services in the future. Interactivity is largely a function of flexible computing power and good software-in sharp contrast to the very high speed but relatively inflexible signal processing done by an HDTV. Declining costs have already brought computers into about 20 percent of American homes.[10] A recent survey, however, found that home computers are used, on average, just twice per week; and many question whether they will penetrate the remaining 80 percent of households any

**Figure 6-1—Sales of VCRs, VCR Prices, and the Growth of VCR Tape Rental Stores**




**Note that the growth of the VCR market corresponds more closely with the opening of VCR tape rental stores than with the decline of VCR prices.**

**SOURCE: Boston Consulting Group, "Development of a U.S.-based ATV Industry," May 9, 1989 for the American Electronics Association. Used with permission.**

time soon. On the other hand, the potentially large household penetration of advanced TVs might allow the delivery of a limited range of user friendly interactive information services to more of the public.

Although interactive videotex systems interest many, experimental systems tested by Knight-Ridder in Miami (1983-86) and Times Mirror in southern California (1984-86) failed. New efforts are underway by Bell South in Atlanta, NYNEX in Vermont, and IBM/Sear's Prodigy throughout the Nation.[11]

In France, the Government-backed interactive Minitel system has been widely noted as a success. There are already *some* 4 million subscribers, although figures for 1988 showed an 8 percent decrease in residential use of Minitel services over the previous year.[12] Minitel succeeded by making use of the existing telephone network; by giving the subscribers interactive terminals; by keeping the

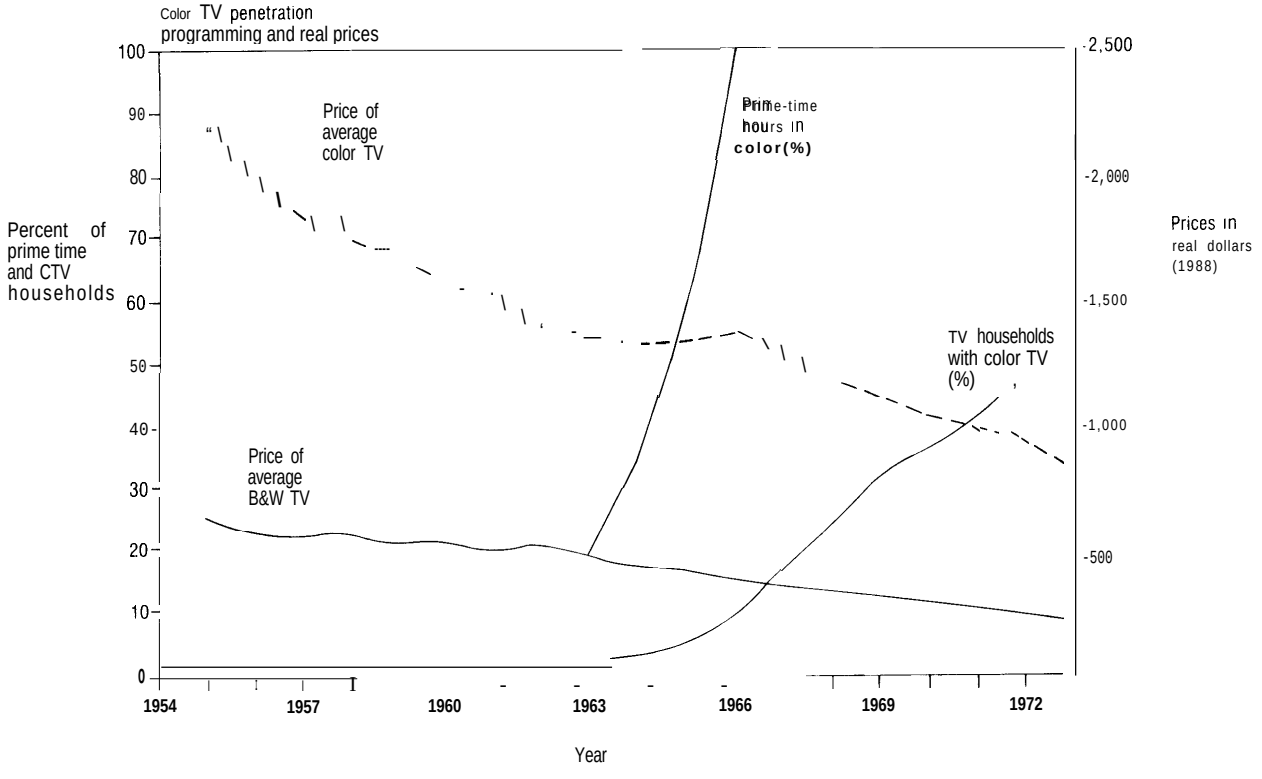
[9]Some have noted that the Betamax VCR format and RCA videodisc were hurt by a corresponding lack of programming. Others note that the problems with both those systems were inadequate technology: the Betamax format only provided 1.5 hours of recording time; the VHS format could give significantly more. Similarly the videodisc technology generated fuzzy pictures compared to alternatives. John Weaver, Liberty Television personal communication, Oct. 12, 1989.

[10]U.S. Department of Commerce, Bureau of the Census, "Statistical Abstract of the United States," table 1286, 1988 ed.

[11]Fredric Saunier, "The Public Network Goes On-Line," *Telephony*, Apr. 3, 1989, p. 26; John Markoff, "Betting on a Different Videotex Idea," New *York Times*, July 15, 1989, p. D5.

[12]Anne-Marie Roussel, "Minitel Gets New Terminal," *Communications Week*, Apr. 17, 1989, p. 52.

**Figure 6-2—Penetration of Color TVs Into American Households, Average TV Prices, and the Share of Prim*Time Programming Devoted to Color TV**




**Note that the prime-time hours in color increased very rapidly beginning in 1963 and that the household penetration of color TVs followed, while the price of color TVs declined only slowly.**

**SOURCE: Boston Consulting Group, "Development of a U.S.-based ATV Industry," May 9, 19S9 for the American Electronics Association. Used with permission.**

terminals simple[13] and their use intuitive; and by providing service on a pay-as-you-go basis.[14] This kept total investment down; allowed potential users to experiment without having to invest heavily before knowing what they were going to get; and avoided the 'chicken-and-egg' problems with users demanding abroad range of services before signing on, and service vendors requiring many users before providing services. At this point, Minitel appears to be no more than a niche market, which has yet to pay for itself (at least in accounting terms), and maybe shifting towards more of a business market.[15]

### *Government Policies and Market Development*

Government policies, particularly those of the FCC, could have a powerful influence on the way the HDTV market develops. The marketplace might establish early standards for VCRs (which are not overseen by the government), for example, that are incompatible with government-backed standards for terrestrial and satellite broadcasting. If such incompatibilities arise between different media or if there is confusion in implementing the standards, consumers may hesitate in purchasing an expensive ATV that has only limited applicability. This could significantly slow ATV market development.

If the FCC allows ATV standards to improve incrementally, with IDTV, EDTV, and other gradual improvements in performance, then consumers may decide to stop short—at least in the near-term-f full HDTV quality, depending on price and viewing

[13]The terminals are now believed to have been too simple and are being upgraded.

[14]Jean Grenier and Georges Nahon, "A Videotex Success Story," *Telephony,* July 27, 1989, p. 46.

[15]James Markham, "France's Minitel Seeks a Niche," *New York Times, Nov. 8, 1988,* p. D1.; Roussel, op. cit., footnote 12; Steven J. Marcus, "The French Videotex Connection" *Issues in Science and Technology,* fall 1987.

preferences. If the standards do not include intermediate enhancements, but move directly to full HDTV, then that market may or may not develop depending on consumers' perceptions of the products usefulness. If NTSC were phased out over a number of yearn in order to make better use of the broadcasting spectrum, then consumers would have no choice but to buy ATVs.

If the FCC requires stations to show the same picture in both NTSC and in HDTV simultaneously, then consumers may decide that the additional quality for the same programming is not worth it. Alternatively, HDTV quality programs and broadcasts might be reserved for special high-end markets, such as pay-cable. Producing and broadcasting HDTV quality programs on special, high-end channels alone presents the same "chicken-and-egg" problems: who invests first-viewers, broadcasters, or program producers? Even detailed consumer studies and market tests can not resolve some of these questions. Ultimately, risks must be taken, particularly by program producers and broadcasters to provide pictures that consumers will want to see. Clear and consistent government policies may be important if potential investors are to take these risks.

## MARKET PROJECTIONS

Despite the lack of audience-based HDTV market research, a number of analysts have projected HDTV markets in the United States. Their forecasts have been made by analogy, i.e., by modeling HDTV penetration rates after those of previous *successful* consumer products such as black and white TV in the late 1940s, color TV in the early 1960s, and VCRs in the late 1970s.[16] There are a number of remarkable market successes such as these. There have also been many market failures, such as the videodisc, quadraphonic sound, stereo AM radio, and others, due to factors ranging from poor technical performance and confusion over standards, to misperception of consumer interests.[17]

Most market projections for HDTV begin by examining the high-end markets where expensive, early production sets will likely be sold. Market analysts then estimate the rate at which cost reductions from economies of scale can bring the price of sets within reach of middle and lower income markets. These models implicitly assume that HDTV will eventually be successful. Furthermore, most of these models assume that the availability of IDTVs and EDTVS will not dampen the market for HDTV, but will instead be part of a natural progression to HDTV.

The projected market penetration rates for successful products normally follow an S-shaped curve.[18] Sales are initially slow. When sales reach a market "take-off" point-typically observed to be a few percent of household penetration-they then grow rapidly. After several years of rapid growth, the market begins to saturate and sales level off to replacement levels. This behavior can be seen in the B&W TV, Color TV, and VCR markets for the United States and Japan (figure 6-3). Eventually, new products may come along that displace the earlier model and cause its sales to decline—such as the case of Color TV replacing B&W. The two principal variables in such scenarios are: 1) at what time the market 'takes off' and 2) how rapidly the market grows after take-off.

HDTV market projections generally follow this form. The Japanese Ministry of Posts and Telecommunications (MOPT) assumes that the Japanese market will take off in 1993. In the United States, the Electronic Industries Association (EIA), National Telecommunications and Information Agency (NTIA), and American Electronics Association (AEA) assume that the market will take off in roughly 1994, 1997, and 2000 respectively. All four of these studies have reasonably similar rates of growth once the take-off point is reached (figure 6-2).

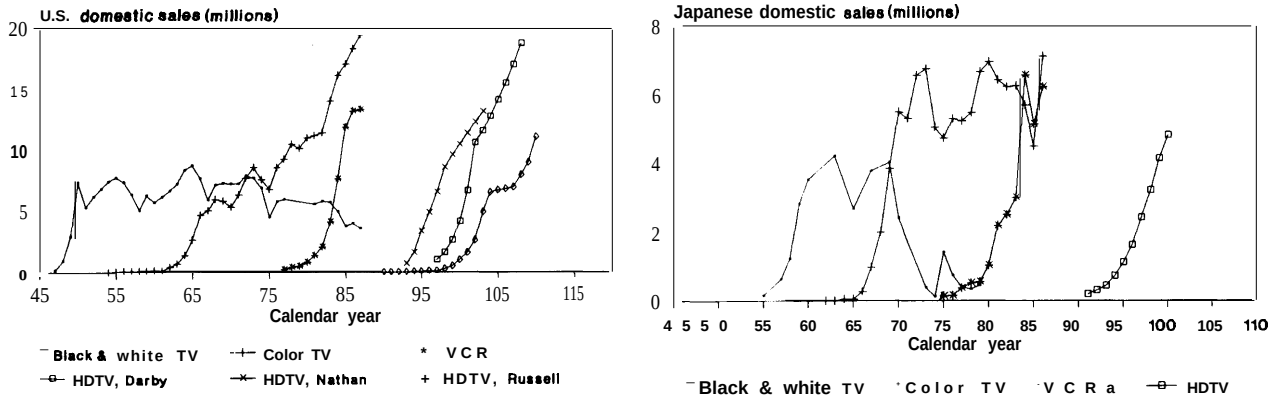
---

[16]Examples of such studies include: Robert R. Nathan Associates, Inc., "Television Manufacturing in the United States: Economic Contributions--Past, Present, and Future," Washington DC, Electronic Industries Association, Nov. 22, 1988; David Russell, "High Definition Television (HDTV): Economic Analysis of Impact," Washington DC, American Electronics Association, November 1988; Larry F. Darby, "Economic Potential of Advanced Television Products," Washington DC, National Telecommunications and Information Administration, Apr. 7, 1988. Reviews of these and other market studies are included in: Shawn O'Donnell, "Forecasting the HDTV Market," Neuman, et al., Feb. 1, 1989, op. cit., footnote 6, appendix; and in Kenneth R. Donow, "EIDTV: Plarming for Action," Satellite Systems Engineering Inc., Bethesda, MD, for National Association of Broadcasters, April 1988.

[17]Steven P. Schnaars, *Megamistakes: Forecasting and the Myth of Rapid Technological Change* (New York, NY: Free press, 1988).

[18]Unsuccessful products follow other paths, including upside down "u" S.

**Figure 6-3-Sales and Projections of Video Entertainment Technologies in the United States and Japan**




SOURCES: *United* States: Electronic Industries Association, "Consumer Electronics Annual Review," various years; Robert R. Nathan Associates, Inc., "Television Manufacturing in the United States: Economic Contributions-Past, Present, and Future," Washington, DC, Electronic industries Association, Nov. 22, 1988; David Russell, "High Definition Television (HDTV): Economic Analysis of Impact," Washington, DC, American Electronics Association, November 1988; Larry F. Darby, "Economic Potential of Advanced Television Produets," Washington, DC, National Teleeommunieations and Information Administration, Apr. 7, 1988.

SOURCES: *Japan:* Electronic Industries Association of Japan, various years; James Howard Wooster, "Industrial Policy and International Competitiveness: A Cass Study of U.S.-Japan @repetition in the TelevisionReceiver Manufacturing Industry," Ph.D. Thesis, University of Massachusetts, 1986; Bob Johnstone, "Programming Better Quality TV," *Far Eastern Economic Review,* Aug. 11, 1988, p. 53.

Others have suggested that the HDTV market could be a big flop,[19] emphasizing the high initial price of HDTVs and questioning whether consumers will see enough additional value over their current sets to justify paying the difference. IDTV and EDTV may themselves fill consumers' needs. Interactive video might create a new competing market, limiting sales of HDTVS (if Open Architecture Receiver designs are chosen as a standard then interactive video and HDTV might be the same market). The experts-the managers of many of the world's consumer electronics fins-have already bet more than $1 billion that there will be a big market for HDTV. Whether they are right or wrong will only be clear in hindsight.

The value of the HDTV market is potentially very large. The Electronic Industries Association has estimated that HDTV receiver sales in the United States could total 13 million units worth about $12 billion[20] retail (1988 dollars) in 2003, $4 billion more than would be the case if the market continued with standard TVs alone. The manufacture of movie production and broadcasting equipment would increase these values even more. Lower estimates include the NTIA Report with sales of $5 to $10 billion in 2003 for 12 million receivers and $3 to $6 billion for 10 million VCRs; and the American Electronics Association report with 2003 sales of 5 million HDTV sets in the United States worth about $5 billion and world sales of about $14 billion. AEA projections give VCR sales of 4 million units adding about $3 billion in the United States; with $8 billion in sales worldwide in 2003. In comparison, the overall U.S. consumer electronics market was worth $30 billion in factory sales in 1987.[21]

These estimates are for home entertainment alone. Commercial and industrial uses may also be important. The Japanese MITI, for example, estimates that sales of consumer goods will be just 60 percent of the total sales of HDTV by 2000.[22]

[19] See, for example, Bob Davis, "Will High-Definition TV Be A Turn-Off?" *Wall Street Journal*, Jan. 20, 1989, p. B1.

[20] All values here are given in 1988 dollars. EIA values were discounted to 1988 dollars at 3.5 percent annual inflation rate from the EIA estimate of $20 billion in 2003. NTIA and AEA published values were assumed to already be in 1988 dollars as they cited no inflation rates.

[21] Electronics Industries Association, op. cit., footnote 3.

[22] "Television Makers Are Yearning of a Wide Crispness," *Business Week,* Dec. 21, 1987; and James G. Parker, TechSearch International, Inc., personal communication, Oct. 6, 1989.

Many widely circulated projections also contain highly questionable assumptions and numerous internal inconsistencies. For example, one report projects that the total TV market in the United States will double in the next 15 years, from 21 to 40 million sets-without identifying who will purchase all these sets as population growth slows and the population ages. It insists that most of the value added will take place in the United States, but glosses over the fact that the high-value manufacturing of electronics for the consumer TV market is today almost entirely offshore-leaving primarily screwdriver assembly operations in the United States. This report also ignores that with the longer term transition to flat panels or projection systems, much of the manufacturing and assembly remaining in the United States could also move offshore. The report assumes that IDTV and EDTV will have no impact on the HDTV market.

The precise course that ATV technology will take and the pace that it will enter cannot be predicted. The development of the ATV market will depend on a variety of factors, including: the rate of technological advance and the achievement of large economies of scale and learning; the consumer response to IDTV, EDTV and HDTV; the development of movies and programs at the appropriate level of visual quality for the ATV technology of choice; and the policies and standards chosen by the government, among others. Improvements in television technology are inevitable, but when and in what form they will take is largely unknown in the longer term.

## MARKET PROJECTIONS AND THE RELATIVE IMPORTANCE OF HDTV

Forecasters have typically compared the relative importance of the HDTV, computer, and other markets by: 1) projecting constant growth rates into the future; 2) comparing the semiconductor content or other component demands for assumed market sizes; or 3) comparing ultimate market penetration rates and corresponding needs per user. None of these are very satisfactory or illuminating.

### *Extrapolating Current Growth Trends*

Extrapolating current or expected growth trends at the same compound annual rate far into the future has been one of the most common techniques for making projections, but this form of analysis can lead to highly exaggerated claims if done carelessly. For example, one report ("A"), has projected constant growth rates of about 5 percent in U.S. TV sales-with about 40 million TVs sold by 2003. A second report (''B") has projected a constant annual growth rate of 10 percent for the computer industry and 7 to 8 percent for the semiconductor industry through 2008. Similarly, a third report ("C") has projected constant annual growth rates of HDTVS and PCs, resulting in annual world sales reaching 180 million HDTVS and 135 million PCs by 2008.

These projections ignore the simple point that sales cannot grow exponentially forever. Markets inevitably saturate. For example, assume that the HDTV market will primarily be in the industrialized countries over the next 20 or so years and that replacements rates will be similar to the 7 year norm experienced for color TV today. With these assumptions, Report C's projection of 180 million HDTVS sold annually in 2008 is roughly equivalent to an ultimate penetration rate of 1.25 HDTVS for every man, woman, and child in the industrial countries. Their projection for personal computer sales, 135 million annually in 2008, gives similarly high penetration rates. These are remarkable, and perhaps unrealistic, penetration ratios.

One can foresee a time that most people in the industrialized world will have a personal computer and an advanced TV. Most people in the United States today have direct access to both a TV and a telephone. There will also be a growing demand for computer technology from the developing countries. Making constant growth projections, as these reports do, is reasonable over short periods of time. Over longer periods markets are likely to saturate and growth projections must be reduced for when this occurs. Even if these very high levels of penetration are reached in the next 20 years, some market saturation will likely occur; but this is not considered in the constant growth rate projections made by these groups.

Comparison of two markets in the distant future based on constant annual growth rates is extremely sensitive to the assumptions. For example, report "C" assumes that personal computer sales will grow from current annual sales of 20 million at a rate of 10 percent; and that HDTV sales will grow from sales of about 5 million in 1994 at a rate of about 30 percent annually. At these rates, HDTV sales are greater than PC sales after the year 2000. But if

HDTV sales instead grow at a still remarkable pace of 20 percent annually, their total sales are slightly less than half those of PCs in the year 2008. Such sensitivity to (as yet) totally unknown underlying parameters makes such forecasting unreliable.

### *Comparing the Semiconductor or Other Component Requirements for Assumed Market Sizes*

Forecasters have also compared the importance of different markets by the relative requirements for semiconductors and other components. This compounds the uncertainties of market growth rates with a lack of regard for the relative importance of various types of components. For example, some have compared the semiconductor content of HDTVS on a simple dollar basis with that of the entire semiconductor industry-rather than within the relevant market segments-and then dismissed HDTV as unimportant as its total semiconductor demand might be relatively small.

With such logic almost any market segment, when compared to the entire industry, can be dismissed as too small to be important. Supercomputers, minisupers, and parallel machines combined were a market of just $1.36 billion in 1988.[23] Assuming a semiconductor content of 10 percent, they would consume just $136 million in semiconductors, compared to a total world semiconductor market of some $54 billion in 1988. Few would argue that the supercomputer industry is unimportant, however; it drives the state-of-the-art in a variety of chip, packaging intercomect, and other technologies as well as that of computers.

Similarly, (MOS) DRAMs were just a $2.5 billion market in 1987 (before the price was driven up by the MITI-coordinated production cutbacks),[24] or less than 5 percent of the total world semiconductor market. But DRAMs drive many important semiconductor manufacturing technologies and the loss of DRAM manufacturing has been a serious concern for both U.S. semiconductor producers and U.S. computer makers. Few would argue that we can do without this market segment despite its small size.

Semiconductors are expected to account for some 10 percent of the retail cost of HDTV receivers.[25] World sales of HDTVS in the various high-growth scenarios might reach $25 billion *or* more by 2003. The corresponding HDTV semiconductor content would be $2.5 billion. In comparison, the world market for semiconductors today is already more than $50 billion with continued dramatic growth expected. Obviously, HDTV would not drive the entire semiconductor industry, but it could add to demand.

It would be a mistake, however, to dismiss the importance of HDTV within specific market segments. In high-growth scenarios, world HDTV use of DRAMs in 2003 could be as much as five times total world DRAM production in 1987 (ch. 5). But this says nothing about the relative importance of this market for DRAMs compared to other uses in 2003. Consider the following scenarios of demand. Both high and low (a tenth as large as the high) scenarios are presented to show the sensitivity of the forecast to underlying assumptions and to caution against the potential pitfalls in extrapolating constant growth trends into the future described above.

Assuming that the world computer, office automation, and telecom/fax markets (the principal users of DRAMs today) grow at an annual rate (by number of units) of 10 percent over the next 15 years and that the intensity of memory use within these products also increases, the resulting total annual growth rate in memory demand (by capacity) over this period would be 20 to 40 percent.[26] At a 20 percent growth rate for all DRAMs, the high-growth scenario suggests that HDTV would represent 25 percent of the total world demand in 2003. But at a 40 percent growth rate for all DRAMs, HDTV would account for just 3 percent of the world DRAM demand. Low

[23]Tekla S. Perry and Glenn Zorpette, "Supercomputer Experts Predict Expansive Growth," *IEEE Spectrum,* February 1989, p. 26.

[24]Charles H. Ferguson, "DRAMs, Component Supplies, and the World Electronics Industry: An International Strategic Analysis," VLSI Memo 89-554, August 1989, Massachusetts Institute of Technology, Cambridge, MA; Kenneth Flamm, "Policy and Politics in the International Semiconductor Industry," SEMI 1SS Seminar, Newport Beach, CA, Jan. 16, 1989; and Kenneth Flamm, Brookings Institution personal communication, Oct. 25, 1989.

[25]Electronics Industries Association "Consumer Electronics, HDTV, and the Competitiveness of the U.S. Economy," House Subcommittee On Telecommunications and Finance, Feb. 1, 1989. Semiconductors will account for a much higher fraction of factory costs, typically 20 percent or more. In the early stages of HDTV production the semiconductor content will probably be higher yet.

[26]Because the market value per unit capability has declined so rapidly for computers and their underlying semiconductor technologies, it is important here to specify that this is by unit capacity rather than by dollar value.

growth scenarios for HDTV would reduce these market shares to 2.5 and 0.3 percent respectively.

In high-growth scenarios, the demand for digital signal and other processing chips for HDTV in 2003 (measured by processing capacity) could similarly be as much as 10 times world production of all logic chips in 1987 (ch. 5). HDTVS might contribute a small to significant additional demand to the total logic market, depending on the assumptions one chooses about growth in the computer and other sectors. In 1989, however, DSPs are forecast to be just 4 percent of the total dollar-value of the logic market.[27] DSP production for all other purposes would therefore have to increase at a phenomenal 45 percent annually for the next 15 years, or 250 times total, just to equal the high-growth scenario demand of HDTV.X Even in low-growth scenarios one-tenth this size, HDTV would still provide a significant demand for digital signal processing chips.

More generally, High-Resolution Systems (which include many computer, office automation, and telecom/fax markets) are likely to account for an important share of DRAM and DSP use in almost any scenario, due to the special processing requirements of video imaging.

If HDTV does provide a large market share for particular semiconductors such as DSPs, it could provide a firm significant economies in production. This has been widely observed for other consumer electronics components and markets. Producing a particular 16-bit digital-to-analog (D/A) converter chip for the large CD-player market, for example, drove their price from $75.00 each to just $3.75, while the price of less complicated 14-bit D/A chips that did not benefit from such a large market demand stayed at $60.00.[29] Such production economies can also extend to individual firms that have the benefit of supplying several markets. This will also tend to insulate the firm from the cyclical swings in demand from a single narrow product segment.

As notedin ch. 5, HDTV is driving the state-of-the-art in many aspects of display technology, and the production volume of displays for HDTV is potentially enormous-as much as 6,000 times larger area of AM/LCD display than is currently produced in the world. Whatever form video entertainment takes in the future, it is likely to continue to be a principal driver of technology and production economies of scale for displays.

Finally, the production of HDTVS may be important in driving the state-of-the-art in some aspects of the manufacturing of sophisticated electronics. High-volume production of consumer electronics has long driven the state-of-the-art in system manufacturing and has had important spinoffs to many other sectors. For example, all the Apple Macintosh's produced for the North American market are made on a TV assembly line in California that was imported from Japan.[30] The development of Tape Automated Bonding, surface mount technologies, and much automated insertion equipment was similarly driven by the consumer electronics industry (ch. 5). Large-volume manufacturing of HDTVS might also teach important lessons in manufacturing, especially because of the sophistication of its electronics.

### *Comparing Ultimate Market Penetration Rates and Corresponding Needs per User*

Although technological progress will continue, the total production volume of computers, ATVs, and telecommunications equipment, etc. will at some point in the future likely slow to roughly replacement levels: there will be a limit to the number of computers, ATVS, videophones, etc. people will be able to put to effective use. At that time, the number of such devices used per person and their relative semiconductor and other component requirements will determine the importance of each market to the semiconductor industry.

Each household, for example, might have an ATV, computer, and videophone at home; a car with some electronics; and a computer/videophone at the office. In addition, there would be a number of ''smart' devices such as microwave ovens, washing machines, coffee makers, and others that would use

[27] See ch. 5; and Integrated Circuit Engineering Corp., "Mid-Term 1988, " Scottsdale, AZ.

[28] Such growth is possible, as seen in the past in the DRAM and other markets. If speech recognition or other such systems enter the market in large numbers over the next 15 years, DSP market growth might be significantly larger than this. This assumes that the cost per gate for DSP is the same as for the larger logic market.

[29] Al Kelsch, National Semiconductor, personal communication, Mar. 15, 1989.

[30] Ferguson, op. cit., footnote 24.

some semiconductors.[31] In this scenario, the ATV would probably have the highest value display. It might then be the principal driver of display electronics and screen technologies and of their production costs. The computer would continue to be the principal driver of microprocessor technology and costs. The computer, videophone, and ATV would all play a role in driving fiber and wideband switching technologies, with the ATV perhaps playing an especially important role in leveraging the extension of fiber to the home. The computer and ATV would share in driving magnetic and optical storage media technology and costs, with the ATV taking a leading role in the near future due to its higher rate of information flow. From this perspective, Advanced TV could play an important role in several sectors.

Basing policy decisions on precise predictions of future markets in the electronics sector is clearly impractical. The market for HDTV, as envisioned today, may or may not develop. HDTV might open up entire new markets unforeseen today; or even substitute for personal computers and telecommunications equipment both at home and in the office. Alternatively, HDTV might be a flop and interactive computer systems prove to be a winner. Such market uncertainty makes investment decisions and policy formulation difficult; in the final analysis, faith may be an important factor in market success.

## TECHNOLOGY AND MARKET TRENDS

The important underlying trends in the technology should not be obscured by the uncertainties in how the HDTV and other ATV markets will develop. No matter what form video entertainment systems take in the future, they will increasingly use digital electronics.

Digital systems allow the manipulation and processing of video information in ways that analog systems cannot. Significant improvements in the quality of the picture presented (ch. 4) and the potential for interactivity will be the result. Digital microprocessors are already common in television tuners, and IDTVs are now on the market. In the longer term, these advantages make the increasing use of digital electronics in TVs inevitable.

HDTV currently exerts greater demands than computer or telecommunications equipment for full-color, high-resolution, W-motion, real-time video. As a result, HDTV is pushing the state-of-the-art in a variety of display, display processor, storage, and certain related technologies. The mutual convergence of Advanced TVs, computers, and telecommunications towards digital video systems and the strong technological push provided by consumer video may result in significant linkages between these sectors.

Technological linkages between components and market segments are undeniably important and not easily quantified. Such linkages, however, can be overstated. For example, report "B" cited above stated that if the U.S. share of the HDTV market is 10 percent or less (weak), then the U.S. share of the world PC market would decline from today's 70 percent to just 35 percent in 2010; and the U.S. share of the world semiconductor market would decline from 41 to 20 percent in the same time period. The report is done so haphazardly, however, that it shows these drops in U.S. marketshare beginning in 1990. Thus, in their scenario the U.S. share of the world PC market even next year oscillates between $34 billion and $17 billion depending on whether or not we have less than 10 percent or greater than 50 percent of an HDTV market that is all but nonexistent-according to their estimate, worth just $4 million in the United States and $92 million worldwide.

As discussed in the previous chapter, there are numerous and important technological linkages between certain aspects of the technologies underlying HDTV, computers, and telecommunications equipment. Some of these linkages are strong; some are weak. In some areas, HDTV will drive the technology; in others computers or telecom equipment will drive the technology. For example, automatic test equipment will be primarily driven by the demands of the computer and telecommunication industries due to the greater complexity, variety, and flexibility of the circuits. Some HDTV proponents have sacrificed credibility and trivialized the importance of these linkages by arbitrarily assuming

[31] This ignores the industrial and military segments which are much smaller.

an instant, across-the-board reduction in market share.[32] Linkages are usually much more subtle, are more often identified only in hindsight, and their impact on related industries and markets is often slow to develop.

The consumer demand for video entertainment and for consumer electronics equipment will always be large regardless of the specific course taken by ATV markets. The Japanese semiconductor industry today is strongly supported by sales of consumer electronics. Roughly one-fourth of total Japanese semiconductor output is currently used in consumer electronics, and TVs and VCRs are a major portion of this.[33]

Perhaps more significantly, large volume mass production, typical of consumer electronics, drives the state-of-the-art in manufacturing technology for systems. These manufacturing technologies, as well as the management practices that go with them, will be important for producers of computer and telecommunications equipment.

In the past, U.S. firms could ignore the consumer electronics market at relatively less cost because analog technologies were used. With the shift of consumer equipment to digital electronics, the linkages to the computer and telecommunication industries are becoming quite important and U.S. fiis can no longer ignore this market with impunity.

The rate at which fiber-optics is extended to the home and the details of how it is connected and made use of is also uncertain. Fiber has already begun replacing the backbone of cable TV and telephone systems. In the midterm, mixed fiber, coaxial cable and copper pair systems (ch. 3) of the telephone and cable TV companies could provide a limited range of interactive video services.

In the longer term, most agree that the improved performance and ultimately lower costs of fiber (and associated electronic equipment) guarantee that it will eventually be used in all new construction and perhaps to replace copper pairs in existing buildings when maintenance costs become excessive. Ultimately, fiber will likely penetrate most households and could then provide a wide range of high-quality information services, however long that may take. The policy question is not whether or not to allow or promote this, but rather how to provide a framework for it to happen most flexibly with the least overall disruption to society.

[32]Examples of this loss of credibility can be seen in: Congressional Budget Office, "The Scope of the High-Definition Television Market and Its Implications for Competitiveness," July 1989; David Wessel, "Mossbacher's Initiative on HDTV Is Getting Scuttled, Sources Say," *Wall Street Journal*, Aug. 2, 1989, p. B2; and Peter Passell, "The Uneasy Case for Subsidy of High-Technology Efforts," *New York Times*, Aug. 11, 1989, p. Al.

[33]Flamm, op. cit., footnote 24; Japan's VCR production accounts for 12 percent of total Japanese chip production: "TV's High-Stakes, High-Tech Battle," *Fortune*, Oct. 24, 1988.