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# CAPITAL MARKET MYOPIA

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## EXECUTIVE SUMMARY

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*The purpose in writing this article is to focus attention on a phenomenon we call capital market myopia, a situation in which participants in the capital markets ignore the logical implications of their individual investment decisions. Viewed in isolation, each decision seems to make sense. When taken together, however, they are a prescription for disaster. Capital market myopia leads to overfunding of industries and unsustainable levels of valuation in the stock market. We use the Winchester Disk Drive industry to elucidate the phenomenon. We argue that capital market participants should have seen the problem coming. They should have known that valuation levels were absurd, based in large part on the greater fool theory. The data necessary to anticipate the problem were readily available before the industry shakeout began and stock prices collapsed.*

*There are several lessons which we believe can be learned by careful examination of the disk drive experience in the period under study. These include:*

***Taking the Broad View of the Industry is the Key to Profitable Investment.*** *The investment mania visited on the hard disk industry contained inherent assumptions about long-run industry size and profitability and about the future growth, profitability and access to capital for each individual company. These assumptions, had they been stated explicitly, would not have been acceptable to the rational investor. Certainly there are valuations which arise which cannot be justified under any circumstance. These are the times for the manager to raise money from the public capital markets. Those managers who took advantage of unsustainable valuation levels now have a chance to survive the shakeout.*

***Growth Is Not Equivalent to Profitability.*** *The high growth rate in the industry made it the focus of considerable managerial, investor and technological attention. The industry attracted so many resources that the growth had high probability of being unprofitable. Excesses in the capital market turned an opportunity into a disaster.*

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**Profits For Some Are Not Equivalent to a Good Business.** Many players made high profits by investing in the hard disk drive business, including the investment bankers and certain of the venture capital groups which invested early enough to "catch the wave" of euphoria in the stock market and still sell under Rule 144. Many others rode the cycle up and down without liquidity. For many buyers of disk drive stocks in 1983, losses were massive. Short-term successes of some gave the illusion of long-term profitability for all. Investors should not be fooled by such inevitably ephemeral successes.

**Market Instability Can Be All Bad News.** Very rapid change often creates entrepreneurial opportunity; it also creates risk. Analysis of the hard disk drive industry reveals the dark side of rapid technological evolution and of customer instability. Early players are often preempted by changes in technology and in customer needs. Early birds are not always winners in product markets, but late comers are almost always losers.

**Recognizing the Chain.** One of the more important lessons to be learned from the tale of the disk drive industry is that all players—entrepreneurs, venture capitalists, investment bankers, industry analysts and investors—must recognize the chains involved in such a process. First, there was a technological chain, a series of bets on technological advances in disk drive components, disk drive designs, and end-user designs. Then, there was a financial chain, a series of related bets on the internal financial health of each player in the technological chain and on the nature of access to capital in the private and public markets. The likelihood that any player in the disk drive industry would prosper without a serious setback due to a weak link was effectively zero. Indeed, weaknesses in the chain were created by exactly the same people whose financial success depended on an unbroken series of favorable outcomes.

During this same period, the public capital markets were also a large supplier of funds to the disk drive industry. The total amount of money raised in public offerings of common stocks for participants in the industry was over \$800 million. During the middle part of 1983, the capital markets assigned a value in excess of \$5 billion to 12 publicly traded, venture capital backed hard disk drive manufacturers. The strong market valuation of these companies paralleled the boom in other high technology stocks and rising valuation levels in the stock market in general. Table 2 contains data on stock prices and valuation levels for some disk drive manufacturers, and Table 3 provides general data on the economy and capital markets.

**F**ROM 1977 TO 1984, PROFESSIONAL VENTURE CAPITAL FIRMS INVESTED ALMOST \$400 million in 43 different manufacturers of Winchester disk drives. The majority of that capital was invested during the last two years, 1983 and 1984, when \$270 million was invested in approximately 51 distinct financing rounds, including 21 start-up or early stage investments. The pattern of these investments is shown in Table 1 (cf. Tables 2 and 3).<sup>1</sup>

The industry served by these companies was experiencing explosive growth by any measure. In 1978, total sales of hard disk drives to the Original Equipment Manufacturer (OEM) market were only \$27 million. By 1983, total sales were approximately \$1.3 billion. Projected sales in 1984 were almost \$2.4 billion, an 84% increase. By 1987, sales were expected to reach \$4.5 billion. Industry data are provided in Table 4.<sup>2</sup>

<sup>1</sup>Data on venture capital investment in the disk drive industry were provided by Venture Economics, publisher of the *Venture Capital Journal* (Wellesley, MA).

<sup>2</sup>Data on the disk drive industry were provided by James N. Porter of DISK/TREND, Inc. (Mountain View, California).

**TABLE 1** Number of Company Financing Rounds and Estimated Amount Invested (\$000) by Disk Drive Technology and by Stage<sup>a</sup>

	1977	1978	1979	1980	1981	1982	1983	1984	Cumulative Rounds ( '77-'84)
<i>All Disk Drive Companies</i>									
Floppy Disks (17 companies)	# 1 \$ 200	6 5955	3 8250	7 19,766	9 23,414	8 30,862	7 29,125	5 16,915	46 134,487
Winchester Disks (43 companies)*	# 2 \$ 780	3 6383	6 5220	5 11,100	12 33,254	19 67,540	22 184,356	20 83,480	89 392,113
Optical Disks (7 companies)	# 0 \$ 0	0 0	0 0	0 0	0 0	1 150	1 9,326	6 15,162	8 24,638
Other Disk Related (6 companies)	# 0 \$ 0	0 0	0 0	0 0	0 0	1 4000	2 11,000	5 21,938	8 36,938
Totals	# 3 \$ 980	9 12,228	9 13,470	12 30,866	21 56,668	29 102,552	32 233,807	36 137,495	151 588,176
<i>Winchester Disk Drives Only, by Stages</i>									
Startup	0	1	1	2	7	8	4	6	29
Other Early	0	1	3	1	2	1	9	2	19
Expansion	2	0	2	2	4	10	14	13	47
Other and Unknown	0	1	0	0	0	2	3	0	6
Totals	2	3	6	5	13	21	30	21	101

<sup>a</sup>Source: These data were supplied by Venture Economics of Wellesley, MA. The 1984 data are likely to be revised as more information arrives.  
\*43 Separate Winchester disk drive companies received 89 rounds of venture capital financing.

TABLE 2 Stock Market Valuations and Return Data<sup>a</sup>

Company	5 year High		Last PO		8/1/83		12/30/83		12/30/84	
	Price	Value	Price	Value	Price	Value	Price	Value	Price	Value
Mimiscribe*	\$14.00	\$214,284	\$11.50	\$202,469	\$1.00	\$15,306	\$11.00	\$190,366	\$3.00	\$51,720
Masstor	\$30.25	396,033	\$16.00	207,840	\$17.75	232,383	\$8.25	108,950	\$3.88	51,786
Rodime	\$28.75	174,426	\$13.75	107,071	\$22.50	136,508	\$21.25	128,924	\$7.00	53,095
Iomega	\$10.13	128,881	\$10.00	130,690	\$10.13	128,881	\$5.63	73,316	\$7.88	106,068
Cipher Data	\$27.50	352,880	\$21.38	278,559	\$19.00	243,808	\$19.75	259,811	\$22.00	298,056
Computer Memories	\$30.00	279,000	\$18.75	209,625	\$26.00	241,800	\$8.00	87,840	\$3.25	35,685
Onyx + IMI	\$22.25	230,822	\$13.00	128,882	\$12.88	133,565	\$9.50	98,553	\$1.38	14,399
Seagate	\$22.13	967,261	\$12.44	543,743	\$17.75	775,995	\$13.88	606,587	\$5.00	220,795
Quantum	\$34.25	313,833	\$20.50	187,452	\$23.25	213,040	\$18.75	172,406	\$21.00	199,836
Micropolis	\$25.00	224,750	\$17.00	156,842	\$19.50	175,305	\$10.75	96,643	\$4.88	43,826
Priam	\$23.25	343,961	\$17.00	258,043	\$19.25	284,785	\$10.75	165,539	\$4.75	77,682
Tandon	\$34.25	1,739,112	\$15.50	788,702	\$30.50	1,548,699	\$20.00	1,015,540	\$6.00	304,710
Total		\$5,365,242		\$3,199,918		\$4,130,073		\$3,004,475		\$1,457,658

Beginning Ending	High	Percentage Change From Period			
		Last PO 8/31/83	Last PO 12/31/83	8/31/83 12/31/84	Last PO 12/31/84
Mimiscribe	-78.6%	1050.0%	4.5%	1000.0%	-72.7%
Masstor	-87.2%	-9.9%	93.9%	-53.5%	-53.0%
Rodime	-75.7%	-38.9%	-35.3%	-5.6%	-67.1%
Iomega	-22.2%	-1.2%	77.8%	-44.4%	40.0%
Cipher Data	-20.0%	12.5%	8.2%	3.9%	11.4%
Computer Memories	-89.2%	-27.9%	134.4%	-69.2%	-59.4%
Onyx + IMI	-93.8%	1.0%	36.8%	-26.2%	-85.5%
Seagate	-77.4%	-29.9%	-10.4%	-21.8%	-64.0%
Quantum	-38.7%	-11.8%	9.3%	-19.4%	12.0%
Micropolis	-80.5%	-12.8%	58.1%	-44.9%	-54.7%
Priam	-79.6%	-11.7%	58.1%	-44.2%	-55.8%
Tandon	-82.5%	-49.2%	-22.5%	-34.4%	-70.0%
All Companies	-72.8%	-22.5%	6.5%	-27.3%	-51.5%

<sup>a</sup>Notes: PO—Public Offering of common stock. These twelve companies were active in manufacturing Winchester disk drives (or tape backups) for the OEM market.

\*Mimiscribe went public on November 3, 1983. The \$1.00 per share valuation listed for 8/1/83 was the last price paid per share by venture capital investors prior to the public offering.

**TABLE 3** Selected Data on the Economy, Public Capital Markets, and Venture Capital Activity<sup>a,b</sup>

Row	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
<i>Macroeconomic Data</i>												
1	1326	1434	1549	1718	1918	2164	2418	2633	2938	3058	3310	3667
2	5.8	8.8	9.3	5.2	5.8	7.4	8.6	9.3	9.4	6.0	4.2	3.8
3	5.8	-0.6	-1.2	5.4	5.0	2.8	-0.3	2.6	-1.9	3.3	6.7	
4	8.8	12.2	7.0	4.8	6.8	9.0	13.3	12.4	8.9	3.9	3.8	4.2
5	4.9	5.6	8.5	7.7	7.1	6.1	5.8	7.1	7.6	9.7	9.5	7.5
6	129.8	129.4	116.3	130.3	138.4	146.8	153.6	146.7	150.4	137.6	147.7	163.2
7	114.9	109.2	107	115.6	123.2	128.2	128.3	122.4	118.6	113.2	115.0	NA
8	329	319	326	376	436	478	525	534	581	567	600	624
9	36.4	38.4	42.6	34.8	28.4	23.9	27.8	42.1	61.3	89.0	NA	79.7
<i>Financial Market Data</i>												
10	7.0	7.9	5.8	5.0	5.3	7.2	10.0	11.5	14.1	10.7	8.6	9.6
11	6.8	7.6	8.0	7.6	7.4	8.4	9.4	11.5	13.9	13.0	11.1	12.4
12	7.4	8.6	8.8	8.4	8.0	8.7	9.6	11.9	14.2	13.8	12.0	12.7
13	8.0	10.8	7.9	6.8	6.8	9.1	12.7	15.3	18.9	14.9	10.8	12.0
14	97.6	68.6	90.2	107.5	95.1	96.1	107.9	135.8	122.6	140.6	164.9	167.2
15	92.2	59.8	77.6	97.9	105.1	139.3	152.3	208.2	223.5	340.7	328.9	258.9
16	58.5	30.9	72.4	116.0	164.0	261.5	369.7	655.7	569.8	715.7	842.6	536.3
<i>Venture Capital and IPO Activity</i>												
17	56	57	10	50	39	600	300	700	1300	1800	4500	4200
18	450	350	250	300	400	550	1000	1100	1400	1800	2800	3250
19	69	9	4	29	22	21	46	135	306	113	477	224
20	160	16	16	145	75	129	183	822	1760	619	3671	1190
21	100	15	15	34	40	45	81	237	448	222	884	548
22	330	51	265	234	153	249	506	1397	3215	1446	12619	3832

<sup>a</sup>Notes: Most of the data in rows 1 through 13 represent averages for the relevant time period. EOY—End of Year Data. IPO—Initial Public Offerings.

<sup>b</sup>Sources: Economic Report of the President; Venture Economics, Wellesley, MA (Rows 16 to 20); Going Public: The IPO Reporter, Howard & Company, Philadelphia, PA (Rows 21 and

TABLE 4 Disk Drive Industry Forecasts<sup>a,b</sup>

	Year of Forecast											
	1979	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	CAGR
Total World Wide	1979	3457.4	3885.4	4502.2	5434.9	6337.0	8988.4	16.4%				
	1980		3816.7	4805.7	6018.7	7684.3	8988.4	23.9%				
(\$000)	1981			5181.2	7037.7	9443.6	11,914.0	14,147.7	28.5%			
	1982				6370.6	7925.3	10,300.8	13,122.0	15,415.0	24.7%		
	1983					7403.4	9331.1	12,072.5	14,557.8	16,943.0	23.0%	
	1984						9112.4	12,922.7	15,623.6	19,088.4	22,608.0	25.5%
Total WW Disk Storage		3457.4	3816.7	5181.2	6370.6	7403.4	9112.4	12,922.7	15,623.6	19,088.4	22,608.0	23.2%
Total OEM-WW	1979	473.3	686.0	806.9	917.5	1008.5	1693.9	20.8%				
	1980		643.6	968.3	1242.0	1494.9	1693.9	27.4%				
(\$000)	1981			835.4	1212.0	1746.2	2201.8	2603.4	32.9%			
	1982				1110.9	1472.1	1950.6	2402.8	2803.3	26.0%		
	1983					1312.6	2038.0	2694.6	3269.2	3728.9	29.8%	
	1984						1940.5	3031.1	3688.7	4377.7	5041.0	27.0%
Total OEM World Wide		473.3	643.6	835.4	1110.9	1312.6	1940.5	3091.1	3688.7	4377.7	5041.0	30.1%
Total Hard Disk OEM	1979	27.1	77.4	167.3	245.1	295.2	81.7%					
	1980		62.0	149.0	327.7	522.5	693.2	82.9%				
(\$000)	1981			99.8	339.3	734.5	1120.6	1480.8	96.3%			
	1982				341.6	770.3	1265.7	1763.2	2175.2	58.9%		
	1983					599.2	1381.6	2097.4	2703.5	3193.1	51.9%	
	1984						1285.0	2358.1	3032.8	3795.7	4493.4	36.7%
Total Hard Disk OEM		27.1	62.0	99.8	341.6	599.2	1285.0	2358.1	3032.8	3795.7	4493.4	76.5%
Summary (\$000):		Actual	Actual	Actual	Actual	Actual	Actual	Forecast	Forecast	Forecast	Forecast	CAGR
Total WW Disk Storage		3457.4	3816.7	5181.2	6370.6	7403.4	9112.4	12,922.7	15,623.6	19,088.4	22,608.0	23.2%
Total OEM World Wide		473.3	643.6	835.4	1110.9	1312.6	1940.5	3031.1	3688.7	4377.7	5041.0	30.1%
Total Hard Disk OEM		27.1	62.0	99.8	341.6	599.2	1285.0	2358.1	3032.8	3795.7	4493.4	76.5%

<sup>a</sup>Notes: WW—World Wide, OEM—Original Equipment Manufacturer, CAGR—Compound Annual Growth Rate. The figures at the end of each row represent compound annual rates of growth for the forecast period. Each row represents a forecast made in a different year.

<sup>b</sup>Source: James N. Porter, DISK/TREND, Inc., from various issues of DISK/TREND Report (Mountain View, CA).

Given these sanguine projections for the industry, the exuberance in the venture capital community and stock market seems somewhat plausible. However, by the end of 1984, the value assigned to those same 12 manufacturers of disk drives had declined from a high of \$5.4 billion to only \$1.4 billion. Further, the fundamentals for almost every participant had deteriorated badly, particularly in late 1984. Losses began to appear, and sales even declined for some companies. One company Seagate, had revenues in each of the first two quarters of 1984 of approximately \$100 million only to have total revenues in the third quarter fall to the \$50 million level. (See Table 5, column 10). For all 12 companies, aggregate net income in the quarter ended September 30, 1984 was only \$2.3 million, down from an average of \$24.2 million in the previous three quarters.

The purpose in writing this article is to focus attention on a phenomenon we call capital market myopia, a situation in which participants in the capital markets ignore the logical implications of their individual investment decisions. Viewed in isolation, each decision seems to make sense. When taken together, however, they are a prescription for disaster.

Capital market myopia leads to overfunding of industries and unsustainable levels of valuation in the stock market. While we will use the Winchester disk drive industry to elucidate the phenomenon, capital market myopia has arisen in many other industries at many points in the past. No doubt, it will occur in the future.

We will argue that capital market participants should have seen the problem coming. They should have known that valuation levels were absurd, based in large part on the greater fool theory. The data necessary to anticipate the problem were readily available before the troubles began. We will try to offer some simple lessons to help investors and entrepreneurs avoid charter membership in the greater fool club.

The remainder of the paper will be divided into four sections:

- *The Winchester Disk Drive Industry (1973–1983)*
- *What happened?*
- *Could the problems have been predicted?*
- *What are the implications?*

## **THE WINCHESTER DISK DRIVE INDUSTRY (1973–1983)**

Winchester disk drives are high-speed data storage devices for computers. The technology was first introduced in 1973 by IBM. After IBM, a number of independent firms introduced competitive products based on the same basic technology. New entrants included Memorex, Control Data, and Storage Technology.

For the most part, these disk drives were designed for use with mainframe computer systems and later minicomputers. The drives were expensive relative to alternative data storage technologies like magnetic tape or floppy disk drives. However, performance of Winchester disk drives was also far superior to these less expensive media.

The mid- to late 1970s were characterized by very rapid technological change in the computer and related peripherals industries. Briefly told, all sectors of the computer industry experienced rapid growth. However, the most rapidly growing sectors were in the mini- and microcomputer industries.

TABLE 5 Sales, Profits, and Margins Data on Disk Drive Companies

Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Year	1977	1978	1979	1980	1981	1982	1983	Period Ended	3 Quarters Ended 9/30/84	Quarter Ended 9/30/84	Cumulative 1977 to 1983
<i>Sales (\$000)</i>											
Muniscribe	0	0	0	0	81	5043	76,591	12/31/83	95,490	26,101	81,715
Masstor	0	5	10	721	2949	19,238	20,170	12/31/83	17,260	6200	43,093
Rodime	0	0	0	0	217	10,871	42,794	9/30/83	47,332	19,300	53,882
Iomega	0	0	0	162	665	1240	7080	12/31/83	32,277	15,700	9147
Cipher Data	9090	14,425	21,572	22,815	55,164	76,429	116,064	6/30/84	103,994	38,894	315,559
Computer Memories	0	0	0	0	2445	16,027	47,428	3/31/84	61,921	30,210	65,900
Onyx + IMI	0	0	1370	14,478	40,940	58,674	74,218	9/30/83	75,208	26,482	189,680
Seagate	0	0	0	9792	40,445	110,411	343,903	6/30/84	252,158	50,600	504,551
Quantum	0	0	0	0	13,656	41,779	67,069	3/31/84	77,400	30,085	122,504
Micropolis	0	3174	8300	11,500	23,900	33,000	51,600	12/31/83	41,338	15,400	131,474
Priam	0	0	0	5997	30,003	63,400	94,300	6/30/84	64,685	20,609	193,700
Tandon	0	1362	3206	6565	22,761	150,500	303,400	9/30/83	311,929	100,000	487,794
Total	9090	18,966	34,458	72,030	233,226	586,612	1,244,617		1,180,992	379,581	2,198,999
<i>Net Income (\$000)</i>											
Muniscribe	0	0	0	(64)	(1040)	(3247)	4788	12/31/83	1161	(2505)	437
Masstor	(750)	(560)	(1390)	(3369)	(8123)	1513	(9377)	12/31/83	(14,800)	(3725)	(22,056)
Rodime	0	0	0	0	(115)	2567	7206	9/30/83	5900	2800	9658

Iomega	0	0	(745)	(3780)	(6063)	(9190)	12/31/83	12	1519	(19,778)
Cipher Data	258	745	75	2236	5161	11,459	6/30/84	10,454	3764	20,909
Computer Memories	0	0	(28)	(369)	1211	1402	3/31/84	2853	1475	2207
Onyx + IMI	0	(865)	473	4455	5186	3661	9/30/83	(4225)	(5871)	11,263
Seagate	0	0	(248)	6949	13,089	42,019	6/30/84	23,586	577	63,610
Quantum	0	0	(1769)	186	7838	10,673	3/31/84	12,187	4687	16,928
Micropolis	0	29	(512)	246	83	3536	12/31/83	1192	102	4080
Priam	0	(1097)	(3747)	1450	4790	9905	6/30/84	3801	624	8414
Tandon	89	163	1507	4505	15,735	23,700	9/30/83	30,583	(1100)	45,860
Total	(403)	(1585)	(6378)	6600	47,863	99,782		72,704	2347	141,532
<i>Net Margin</i>										
Miniscribe	0.0%	0.0%	0.0%	-1284.0%	-64.4%	6.3%	12/31/83	1.2%	-9.6%	0.5%
Masstor	0.0%	-11200.0%	-467.3%	-275.4%	7.9%	-46.5%	12/31/83	-85.7%	-60.1%	-51.2%
Rodime	0.0%	0.0%	0.0%	-53.0%	23.6%	16.8%	9/30/83	12.5%	14.5%	17.9%
Iomega	0.0%	0.0%	-459.9%	-568.4%	-489.0%	-129.8%	12/31/83	.0%	9.7%	-216.2%
Cipher Data	2.8%	5.2%	4.5%	4.1%	6.8%	9.9%	6/30/84	10.1%	9.7%	6.6%
Computer Memories	0.0%	0.0%	0.0%	-15.1%	7.6%	3.0%	3/31/84	4.6%	4.9%	3.3%
Onyx + IMI	0.0%	0.0%	3.3%	10.9%	8.8%	4.9%	9/30/83	-5.6%	-22.2%	5.9%
Seagate	0.0%	0.0%	0.0%	17.2%	11.9%	12.2%	6/30/84	9.4%	1.1%	12.6%
Quantum	0.0%	0.0%	0.0%	1.4%	18.8%	15.9%	3/31/84	15.7%	15.6%	13.8%
Micropolis	0.0%	0.9%	8.4%	1.0%	0.3%	6.9%	12/31/83	2.9%	0.7%	3.1%
Priam	0.0%	0.0%	-62.5%	4.8%	7.6%	10.5%	6/30/84	5.9%	3.0%	4.3%
Tandon	0.0%	12.0%	23.0%	19.8%	10.5%	7.8%	9/30/83	9.8%	-1.1%	9.4%
For All Companies	-4.4%	-8.4%	-8.9%	2.8%	8.2%	8.0%		6.2%	0.6%	6.4%

TABLE 6 Common Stock Offerings<sup>a, b</sup>

Summary of all public offerings (PO) of common stock								
Column	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Company	Offering date	Total shares (000)	Price per share	Gross amount (\$000)	Implied value (\$000)	Actual net to co. (\$000)	Value/TTM sales	PO ownership (%)
Miniscribe	Nov-83	2300	\$11.50	26,450	202,469	24,130	7.3	13.1%
Masstor	Mar-83	3000	\$16.00	48,000	207,833	39,565	10.8	18.4%
Rodime	Sep-82	1100	\$8.00	8800	40,477	8078	404.8	21.7%
	Mar-83	1375	\$19.00	26,125	117,644	17,616	13.4	18.2%
	Apr-84	1725	\$13.75	23,719	107,069	21,000	3.0	22.2%
Iomega	Jul-83	2420	\$10.00	24,200	130,690	20,909	163.4	18.5%
Cipher Data	Oct-81	2420	\$4.75	11,495	37,339	10,291	1.6	30.8%
	Oct-82	2882	\$8.88	25,578	93,232	22,129	1.3	24.6%
	May-83	2200	\$21.38	47,025	278,559	45,412	3.9	16.9%
Computer Memories	Jan-82	660	\$7.00	4620	21,595	5220	108.0	21.4%
	Dec-82	930	\$16.25	15,115	100,389	13,717	12.0	11.1%
	Aug-83	2200	\$18.75	41,250	209,629	30,656	8.9	16.8%
Onyx + IMI	Apr-81	1300	\$13.00	16,900	128,883	17,525	8.9	13.1%
Seagate	Sep-81	6600	\$5.00	33,000	185,237	25,865	18.9	15.1%
	Feb-83	6600	\$12.44	82,088	543,735	71,987	9.5	15.1%
Quantum	Dec-82	2750	\$20.50	56,375	187,460	31,477	6.3	18.3%
Micropolis	Jun-83	2599	\$17.00	44,183	156,837	39,180	4.2	26.9%
Priam	Jun-83	4235	\$17.00	71,995	258,036	66,594	5.0	27.9%

Company	Balance sheet date	Total share equity (\$000)	Retained earnings (\$000)	Net \$ from all POs (\$000)	RE/SE (3)/(2)	IPO/SE (4)/(2)	Cumulative PO own (%)	
Tandon	Feb-81	2173	\$16.00	34,767	138,642	17,533	4.8	13.8%
	Nov-81	1980	\$29.50	58,410	322,748	53,007	6.0	18.1%
	Nov-82	3300	\$31.00	102,300	788,689	88,755	5.2	13.0%
Total		44,398		802,393	4257192	670,647		17.6%
Miniscribe	12/31/83	41,829	437	24,130	1.0%	57.7%	13.1%	
Masstor	12/31/83	47,842	(21,960)	39,565	-45.9%	82.7%	18.4%	
Rodime	6/30/84	53,258	7286	46,694	13.7%	87.7%	50.7%	
Iomega	12/31/83	17,932	(19,873)	20,909	-110.8%	116.6%	18.5%	
Cipher Data	6/30/84	104,834	20,795	77,832	19.8%	74.2%	55.3%	
Computer Memories	3/31/84	51,809	2206	49,593	4.3%	95.7%	28.8%	
Onyx + IMI	9/30/83	31,779	10,969	17,525	34.5%	55.1%	13.1%	
Seagate	6/30/84	165,026	63,610	97,852	38.5%	59.3%	27.9%	
Quantum	3/31/84	60,311	16,928	31,477	28.1%	52.2%	18.3%	
Micropolis	12/31/83	59,780	4352	39,180	7.3%	65.5%	26.9%	
Priam	6/30/84	91,020	8171	66,594	9.0%	73.2%	27.9%	
Tandon	9/30/83	212,030	45,835	159,295	21.6%	75.1%	25.5%	
Total		937,451	138,756	670,647	14.8%	71.5%		

<sup>5</sup>Source: Securities Data Corporation (New York, New York) and company documents.

<sup>6</sup>Notes: PO—Public Offerings, including Initial Public Offerings (IPOs). TTM Sales—Trailing Twelve Month Sales. RE—Retained Earnings. SE—Shareholders Equity. PO Ownership or PO Own represents the share of the company's stock owned by buyers in public offerings.

As had always been the case in the computer industry, there was an inexorable increase in the performance of machines combined with a decline in cost. This statement was true of the computers; it was also true of peripherals such as disk drives. The cost of 10-megabytes of hard disk capacity in 1973 was almost \$40,000; by 1983, the same 10-megabytes cost one-tenth as much. Equally importantly, as mini- and microcomputers increased in power, so too did data storage requirements. Hard disk drives were tailor made to meet these needs.

By the late 1970s, many analysts predicted an especially bright future for suppliers of hard disk drives to the OEM marketplace. One prominent analyst, Jim Porter of *DISK/TREND Reports*, predicted in 1979 that total sales of hard disk drives to the OEM market would be almost \$700 million by 1983, up from only \$27 million for all of 1978. The following year, Porter was forced to revise upward his forecast: total 1983 sales were expected to be \$1.1 billion, followed by \$1.5 billion in 1984. The pattern of rising expectations is shown in Table 4.

These projections did not go unnoticed in the industry. A number of executives in firms active in the data storage industry decided to go after a share of the OEM market. Typical were some executives at Memorex, one of the early entrants into the Winchester disk drive industry after IBM. William Schroeder, a product planning manager, and Al Wilson, a disk drive project manager at Memorex with 27 years of disk drive engineering experience, left Memorex in 1978 to form Priam Corporation to produce high-performance 14-inch disk drives for the small business computer market. Priam's drives would incorporate the same basic technology as had been used by IBM in its initial product in the area, but would be much less expensive to manufacture.

Priam was able to garner capital funding from some of the leading venture capital firms. The venture capital community was attracted to the industry because of the explosive growth prospects. Moreover, the quality of the entrepreneurial team at a start-up like Priam was very high.

Early entrants into the OEM disk drive industry focused on bringing the high end disk drive technology to the mini- and microcomputer market. These firms were confronted with many difficult issues. Basically, they were shooting at a moving target. They had to make myriad decisions about technology, production and manufacturing, marketing, and finance.

Priam, for example, started essentially from scratch in 1978. Early work centered on designing a 14-inch, 34-megabyte Winchester drive for sale to OEMs. Before production could begin, however, competing firms announced plans to introduce competitive 8-inch products. Priam was forced to start a parallel development effort for an 8-inch line of drives. Finally, Priam, like other start-ups, had to design a complete manufacturing system in an industry in which quality control was absolutely essential.

Many other start-ups joined Priam in entering the market. Each new entrant learned something from previous entrants in terms of how to attack particular industry problems such as manufacturing. Each used the best available technology. Each later entrant also benefited from new information about the nature of the market, and could thus tailor their own plans to match the needs of the OEM industry.

Many of the new entrants were started by seasoned executives from the disk drive industry. Memorex, an early producer of disk drives, was an especially fertile supplier of start-up management talent. The founders of Priam came from Memorex. So too did the founders of Seagate, Tandon, Miniscribe, and International Memories (the "IMI" in Onyx-IMI), some of the more successful disk drive manufacturers.

As the industry evolved, there were many dramatic shifts in the marketplace. One of the most important was the move towards smaller dimension disk drives, first from 14-inch to 8-inch and later to the 5.25-inch size. Projections called for the 5.25-inch segment to grow at the fastest rate.

The first product announcement of a 5.25-inch product was by Seagate, a company which had been founded in 1979 by Alan Shugart. Shugart had been an executive at IBM, then Memorex, and had launched another company called Shugart Associates in 1973 to produce high capacity floppy disk drives. Shugart Associates had been sold to Xerox in the mid-1970s. Seagate first began shipping a 5.25-inch, 6.38-megabyte drive in July 1980, slightly less than two years after the company had been founded. During the first year of operations (ended June 30, 1981), Seagate reported sales of almost \$10 million and a net profit of \$1.8 million. The company had been financed by professional venture capital, and by Dyan Corporation, a manufacturer of high-quality floppy diskettes.

Finding equity capital to fund start-ups in the industry was relatively easy. The industry growth prospects were excellent. The entrepreneurs were extremely well-qualified. Some, like Alan Shugart, had already been involved with successful ventures. Others, like Vertex Peripherals, a late 1981 start-up focusing on the 5.25-inch disk drive segment, had top executives who cumulatively had over 100 years of disk drive industry experience.

Equally important, the late 1970s and early 1980s were characterized by a sharp increase in the level of funds available for venture capital investment. From an almost imperceptible \$10 million in new capital committed to the venture capital industry in 1975, \$1.3 billion was committed in 1981. Key factors underlying the explosion in venture capital activity included the 1978 and 1981 decreases in capital gains tax rates, the 1979 liberalization of pension fund investment regulations under E.R.I.S.A., and the wealth of opportunities to create new companies triggered by factors ranging from technology (e.g., the microprocessor chip) to deregulation of industries from airlines to financial services.

The period from the mid-1970s to the early 1980s was also a period of robust stock market performance. The stocks of smaller companies, including many high technology companies, had been stellar performers from 1975 to 1981. Higher prices for stocks and greater venture capital activity also was a contributing factor in the reemergence of the new issue market. From a low in 1975, in which four companies with a net worth of under \$5 million raised \$16 million, 306 small companies raised \$1.7 billion in 1981 alone. These trends were reflected in the market as a whole as shown in Table 3.

With respect to the disk drive industry *per se*, the ebullience of the initial public offering (IPO) markets was an important factor in the development of the industry. First, a number of firms began to raise capital through the public market rather than continued reliance on venture capital funding. Seagate, for example, raised \$26 million net in September 1981, having only introduced its first product in July 1980. The value assigned to Seagate after that offering was \$185 million, over 18 times trailing 12 months sales. Tandon, Cipher Data, and Onyx + IMI (then called Dorado Systems) also raised money in the IPO market on favorable terms during 1981. In fact, Tandon actually raised money twice in 1981, \$17 million in February and \$53 million in November of the same year. Data on all public stock offerings by some of the disk drive companies are provided in Table 6.

The fact that the IPO market was receptive to disk drive companies was very important in several dimensions. First, the IPOs revealed how intensely profitable investments in disk drive companies could be. The venture capitalists in Seagate had paid \$1 million for 17%

of the company. Their share of Seagate's total post-IPO market value was worth almost \$32 million.

The second reason why an attractive IPO market was important was that the venture capitalists were able to see a way in which they could convert illiquid letter stock holdings into liquid holdings of registered common stock. During the mid-1970s, harvesting of venture investments had been very difficult because there was no IPO market. Many investments were liquefied through mergers. The existence of an IPO market with high valuations was a very important factor in attracting venture capital investment in the disk drive industry as well as many other high potential industries at the time.

The final and obvious reason why the hot IPO market was important in shaping the industry was that the participants in the industry were able to raise large amounts of equity capital on attractive terms. Table 6 also shows the percentage of the total equity capital provided by public stock offerings and the percentage of total shares outstanding attributable to the public owners of the company as a result of their cash investment.

The events described above in the 1980 to 1981 period set the stage for even more impressive venture capital and IPO activity in 1982 and particularly 1983. In 1982, \$1.8 billion was infused into the venture capital industry. This was followed in 1983 by \$4.5 billion. These figures should be contrasted with the \$10 million in new capital committed in 1975. The \$4.5 billion in 1983 was approximately equal to the entire amount invested over the preceding five years. Not only did existing firms raise record amounts, many new venture capital partnerships were formed in 1982 and 1983.

Beginning in 1981, venture capital began to pour into the Winchester disk drive industry. In 1981, 12 different companies were funded. The following year, 19 companies were funded, and in 1983, 22 Winchester disk drive companies received venture capital investments. In total, slightly over \$300 million was invested by venture capitalists from 1977 to 1983. This figure in turn represented just under 4% of the total capital invested by the venture capital industry over the same period. (See Tables 1 and 3.)

With respect to the IPO market, in 1982, 113 small companies raised \$619 million, down significantly from 1981. However, during 1983, 477 companies with a net worth less than \$5 million raised \$3.7 billion in the new issue market. The year 1983 was remarkable for all new issues: a staggering 884 companies raised over \$12 billion, shattering all previous records. (See Table 3.)

During 1982 and 1983, a number of disk drive companies went public or raised new money in the stock market. A sample of 12 of the major industry participants sold stock worth over \$600 million in 1982 and 1983. Of that amount, over \$50 million was raised by selling shareholders. As of the public offerings, the median total market value assigned to those companies going public was approximately six times trailing 12 months sales. For the subset of companies going public in the 7 months ended July 1983, every IPO was characterized by an increase of at least 10% in shares being offered and 20% in price, when compared to initial estimates in the preliminary prospectuses filed with the SEC. Investors clamored for new issues in disk drive companies. (See Table 6.)

## **WHAT HAPPENED?**

To summarize, the period from 1977 to 1983 was one in which a number of factors combined which resulted in a massive infusion of capital—from venture capitalists and from the capital markets—into the Winchester disk drive industry. First, the product market was perceived

to be very attractive. There was an ample supply of management talent. There was also an ample supply of risk capital on very attractive terms, particularly from the public capital market.

The outcome of the confluence of these factors was a remarkable chapter in American business history. A company like Seagate went from a standing start in 1979 to attain revenues in the year ended 12/31/83 of \$223 million with net income of over \$30 million. A number of the other participants showed similarly striking records through 1983. The sales and net income records of the public companies are shown in Table 5.

The total industry grew at a remarkable rate during the period from 1979 to 1983. To illustrate, total disk storage industry revenues rose from \$3.5 billion in 1978 to slightly over \$9 billion in 1983. The OEM segment of the industry increased from \$473 million to \$1.9 billion over the same period. And, the hard disk drive segment of the OEM disk drive industry experienced a sales increase from \$27 million in 1978 to \$1.3 billion in 1983. Projections called for 1987 revenues of \$22.6 billion for the entire disk drive industry, \$5.0 billion for the OEM segment, and \$4.5 billion for the hard disk drive portion of the OEM market. (See Table 4.)

The spectacular performance of the industry and of the companies was reflected in valuation levels in the stock market. The highest valuations were attained in mid-1983. The aggregate market value of the twelve public companies during 1983, measuring each at the high for the year, was \$5.4 billion.<sup>3</sup> This figure can be compared to total sales for the year for these companies of \$1.2 billion, and total net income of \$100 million. Sales and net income for the previous year were \$587 and \$48 million, respectively.

To put the valuation figures in perspective, the mid-1983 total market value of Burroughs, Control Data, Honeywell, NCR, and Sperry was only \$12.8 billion on 1983 sales and net income of \$22.2 and \$1.1 billion, respectively. (See Tables 2 and 5.)

Equally revealing is a comparison of the lofty valuation figures for the disk drive companies with those accorded a broad mix of companies at about the same time. To illustrate, at the end of 1982, for \$5.5 billion an investor could have purchased a portfolio comprised of the following 10 companies: Commerce Clearing House, Paine Webber, SCOA Industries, Tuscon Electric, Cray Research, Potlatch, Emhart, ALCO Standard, Belco, and Norton Simon. In 1982, these companies generated \$11.8 billion in sales and \$546 million in net income.

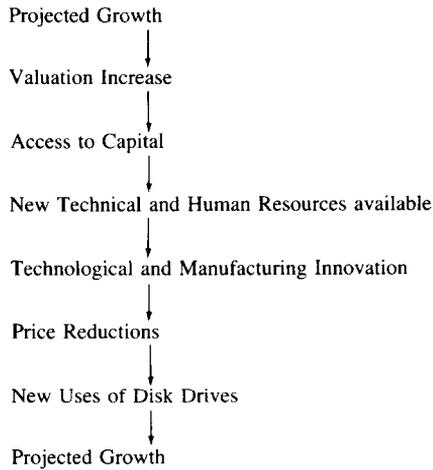
Similarly, at the end of 1983, for \$5.5 billion an investor could have purchased a portfolio comprised of the following companies: Clorox, Coastal States, Wachovia Bank, MAPCO, MGM United Artists, Payless Cashway, NCNB and Premier Industries. The total sales and net income for these 8 companies in 1983 were \$12.4 billion and \$504 million, respectively.

Finally, when making these valuation comparisons, it is important to note that a large percentage of the income generated by the hard disk drive companies came from interest income on excess cash raised in the IPO market. Specifically, in 1983 (see Column [7] of Table 5), the 12 disk drive companies had \$25 million in net interest income. Only 2 of the companies actually had net interest expense in that year.

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<sup>3</sup>The highs for each of the companies were recorded in a relatively short time frame from May to July 1983. An exception was Miniscribe which did not go public until November 1983.

To summarize, the industry had benefited substantially from the chain of success:



However, while the industry as a whole and individual companies made tremendous strides in fundamental operating performance during this period, many companies ran into difficulties. The sources of problems were many, but fell into a few broad categories: technology, manufacturing, market development, customer base, competitive, and financial.

In the technology area, the fundamental fact of life in the hard disk drive industry was that disk drives were complicated products to design and manufacture. Moreover, there were many different possible ways to design drives. As new firms entered the market, more ambitious standards were set for all the competitors in terms of product performance traits. However, in order to accomplish these ambitious goals, new related technology in areas such as platter media would have to be made. Some companies, such as Evotek, were never able to create the product envisioned in their business plans because media suppliers were never able to supply them.

Even when a product could be created in test quantities (essentially by hand), the transition to volume manufacturing was fraught with difficulty. The quality control standards for hard disk drives were exceptionally high, and the manufacturing requirements exacting. Some companies were able to produce sufficient acceptable quality drives at low levels of production, but experienced disastrous quality control problems when operating at higher rates.

Furthermore, the OEM marketplace to which the disk drives were directed was not an easy market to sell. Several issues arose. First, while the total industry was experiencing explosive growth, it was not always clear who the winners would be. Many of the customers of the disk drive manufacturers were not very solid in terms of financial health or market penetration. For some of these customers, betting on a new supplier of better, cheaper disk drives was easy. However, these customers were not always the best kind of customers. When the computer industry began a shake out in late 1983 and 1984, many of these companies folded, including Eagle, Franklin, Osborne, and others.

Even the "good" customers like IBM or Hewlett Packard did not always turn out to be very good. IBM was a notoriously tough buyer. For a small company to have IBM as

its largest customer was akin to playing Russian roulette. Customers like Digital Equipment or Hewlett Packard were less cutthroat, but did not always achieve the market penetration they had forecast when signing up disk drive suppliers.

The other characteristic of the OEM marketplace was that some industry pundits and participants seem to have fallen into the log-linear extrapolation trap. That is, projections called for continued very high growth rates. However, in 1983 there was a significant downturn in the rate of growth of computer sales when compared to projections. Companies whose plans were based on the more optimistic projections experienced great difficulty. They were caught on the horns of the classic growth industry dilemma. If they did not staff, build, and finance for growth, they could never achieve it. If they prepared for growth and it did not arrive on schedule they were faced with the painful and often permanently damaging need to scale back people and plant *and* give great disappointment to the financial backers.

The greatest single industry-wide problem that arose in 1983 and 1984 was the increased intensity of competition. Any industry with over 70 companies vying for a share in the market is an industry in which margins are difficult to sustain. Price cutting to get "designed-in" was rampant. Prices fell more rapidly than anyone had predicted. Given high fixed costs, including R&D, margins fell sharply.

The competitive battle took place on dimensions other than price as well. As noted earlier, each new entrant came equipped with a better or less expensive technology. Firms already in the marketplace were buffeted with demands from OEMs for better products. There was essentially no customer loyalty in this kind of market, except that enforced by the nature of the product and the "design-in" phenomenon.

The competitive battles made continued expenditures on R&D a necessity. However, continued R&D increased the rate at which cash was consumed (the "burn rate") without any necessary return. Often, companies had geared up to meet high growth rates but then had to scale back when the company's market did not develop as fast as thought. Managing hyper-growth is hard; managing vacillating hyper-growth is near impossible.

All of these factors combined to put intense pressure on the financial resources of the companies in the industry. For the public companies, many had raised capital in the markets which made them better able to weather the storm. For the private companies, the problem was more serious. These companies were dependent on the venture capital and banking industries to supply necessary capital.

However, few problems are tougher for venture capitalists or bankers than to be confronted with deciding whether or not to put more money into a situation which develops slower than anticipated. It always seems that the next \$1 million is all the company needs, but history shows this is a fallacy.

In this regard, the marked slowdown in the IPO market in late 1983 and the tremendous decline in the prices of some of the leading disk drive firms from mid-1983 to late 1984 caused especially troublesome problems. Basically, the public capital markets were no longer a viable source of funds for the disk drive industry. (See Table 3.) One firm, Miniscribe, which went public in November of 1983 had to scale back the number of shares being offered from 3 to 2 million and the price from \$15.00 to \$11.50. Nor were the public capital markets available to some of the firms which supplied the drive manufacturers or firms which used their products.

The venture capital market also experienced a significant decline in available funds in 1984. First, the amount of new capital committed declined to \$4.5 billion from \$4.2 billion in 1983. Second, more money had to be set aside for investment in expansion stage financing for portfolio companies, given slow progress of those companies and the less attractive IPO

market. By mid-1984, valuations in the venture capital market were down by over 40%. This decline in valuation levels mirrored a decline in the level of the Venture 100 Index of 43% from June 1983 to June 1984 and 24% from December 1983 to June 1984.

### **COULD THE PROBLEMS HAVE BEEN PREDICTED?**

It is always tempting to rely upon *ex post facto* analysis in order to demonstrate one's brilliance. In the case of the hard disk drive industry, however, much of what has happened was imminently predictable. The year 1982 was critical in the industry. Almost two-thirds of the venture capital investments were made in 1982–1984. Twenty-one out of twenty-six issues of common stock associated with disk drive companies occurred in that same period. The question for *a priori* prediction is what could have been known and what should have been known. In order to address these questions we have looked at the critical bets which were being placed and at the sources of information which were readily available at the time.

#### **Identification of Critical Bets**

In studying this industry in 1982, five critical bets were identifiable as determining economic success in the business. These five bets were in disk drive technology, customer development, market maturation, manufacturing technology, and in the future requirements for research and development. In order to have a successful company, as distinguished from a profitable short-term investment, all five bets had to have favorable outcomes. The questions raised in the analysis were relatively simple. We shall examine the bets in turn.

#### *Technology*

Two issues were clearly important in the technological evolution: Would other computer systems components be developed that could utilize the projected power of the new hard disks being designed? Would the parts which make up the disk drive be available on a basis of timeliness, cost, and technical performance which would allow assembly of the finished product? These two bets were in many ways independent. The first depended upon accurate assessment of the state of the progression toward standards in the OEM marketplace. By that time (ca. 1982) apparent standards did exist for controllers, data transfer protocols, etc. Innovative high performance disk drive designs not conforming to industry standards often met OEM resistance rendering many of the performance improvements unattainable. Some nonconformist designs were rejected outright.

The second technological issue meant that the manufacturers of the hard drives themselves were basing their economic future on the emergence of qualified, reliable suppliers of critical components, including heads, platters, motors, and controls. In many cases these supplier firms were also new and untested and their specifications were elements of their own ambitious business plans. Thus the emerging company had to bet both that others saw the same technical solutions and that these suppliers would deliver on time and on budget. Many contemporary comments were made regarding the lack of judgment on the part of competitors in such reliance. Unfortunately, the name of the money raising game became having the "highest spec" product, so that for the latest disk drive entrant, the basis of initial competition became integrating all possible state of the art advancements. Such products

were based on yet to be introduced supplier technologies, and were intended for use with yet to be designed computer systems components (e.g., controllers) in yet to be designed computers.

### *Customer Development*

As noted previously, two types of customers were emerging: the conservatives and the adventuresome. In many cases, the conservatives were the customers who had established markets, marketing, and production facilities. Their primary concern became on-time delivery without the 30 percent “dead on arrival” factor which characterized many drive manufacturers. The other players in the computer systems market soon emerged as the major market for “the innovators.” These customers were in a specifications war themselves and wished to be armed with the most advanced weapons. They were quick with the purchase order, since that often guaranteed a place at the front of the delivery line if shortages materialized. Unfortunately, these same firms were often slow with payments for any other than evaluation samples. They too were dependent on the disk drive manufacturers. They often had other dependencies as well, including their own in-house development processes. It made no sense to have many drives on hand if there were no way to assemble them into a final deliverable package.

Ultimately, then, success for drive manufacturers hinged either on breaking into the credibility circle to become a supplier to a major (e.g., Digital Equipment or Hewlett Packard) or else making the right bet on which of the hundreds of houses which had hung out the systems integrator shingle were going to survive. Market credibility and financial strength had to be the *sine qua non* of customer selection. Unfortunately for the newly emerging firm, breaking into the credibility circle was time consuming, costly, and did not necessarily take advantage of the technological breakthroughs which had motivated formation of the venture in the first place. Basing a strategy on the emerging new computer firms exposed them to the risks associated with being a link in a chain of new ventures. At best, they could be a part of the success. At worse, they could be exposed to one of three critical sources of failure—financial default of a major customer such as Otrona, Osborne, Eagle, etc.; technological usurpation by another emerging supplier with better, faster, or cheaper specifications; or missing a critical deadline for a customer within the “credibility circle.”

### *Market Maturation*

The new venture in the disk drive industry was subject to the normal forces of market maturity. The computer industry had exhibited the same pattern repeatedly: technological-based competition evolved into service-based competition evolved into price competition. The rapidity of new product development in the field left some with the hope that the competition would remain technological based. However, it soon became clear that OEM customers looked to the disk drive suppliers as unenthusiastic allies in price-based battles. Even worse, the possibility was present from the start that the competitive battles would take place on both a technological *and* a price basis, particularly given the intense competitive war being waged in the OEM computer market.

A second feature was also present regarding the pattern of industry structure. Many of the drive customers were knowledgeable in both the technology and manufacturing arenas. There was a significant threat of forward integration on the part of the major OEM accounts.

The product had many characteristics that would encourage such integration: it was expensive, critical to long-term performance, shared many operations in scope with other manufacturing steps and could be sold to others without impinging on the proprietary technology at the core of the business. Furthermore, the industry was faced with certain knowledge that many of the critical steps in the manufacturing process were of interest to formidable competitors offshore in Japan, Korea, and Singapore. The *only* barrier to vertical integration and to massive foreign entry was the fact that a large, standardized market had not yet been proved to exist. Thus, normal patterns of market maturation in the computer industry would indicate rapid drops in margins that could only be arrested through dramatic increases in sales volume. In this regard, it is interesting to note that in mid 1983 there were 63 active suppliers of disk drives to the OEM market. Of these, 17 had both OEM Sales *and* captive sales; and there were 21 Japanese and European companies active in the OEM market already.

### *Manufacturing Technology*

The most critical assumption in many cases was that the product could be produced at a price which would yield profits. In many cases, manufacturing cost assumptions were based on straight line projection of rapid cost decreases. Such projections were based upon experience with the storage media which heretofore had large electronic components. The question was: could such experience be translated to the highly significant electromechanical component in the hard disk drives? Many of the significant technologies: plating, motor control, and positioning were more dependent on mechanical than electronic developments. The pricing decisions for some entrants seemed predicated on learning curve effects which seemed unlikely to pan out.

### *Future Research and Development*

The final critical bet as to the success of the companies being funded was with respect to research and development activities. In many cases, companies were founded around a basic technological idea which had its origins at previous employers. For many of the companies, the first two or three years were devoted to perfecting the application of the idea and to "ramping up the manufacturing." Few companies could afford the luxury of pursuing a second generation product while the first generation was as yet unproduced. However, it was clear from the continuing stream of product announcements and new company formations that the rate of progress of the technology would continue unabated. The successful company, at a minimum, would have to be prepared for a sequence of technological breakthroughs, not just the initial launch. Even more complex was the self-evident requirements for increased integration. The components of the hard drives—heads, platters, motor controls, arms, and electronics—were coming from outside suppliers, many of which had uncertain futures. The controllers and data channels were coming from other producers. It seemed obvious that many competitors would be either integrating forward from the components to the manufacture of whole drives, or backward to the components. These changes in industry structure would require careful strategic planning. Furthermore, they would tax the already strained research and development capacities of the nonintegrated players.

In sum, there were five key areas of uncertainty confronting entrants into the disk drive industry and their financial backers. A truly successful venture would only result from simultaneous positive outcomes on all five bets.

## What Could Be Known?

The above analysis was based on data available in the public domain. Information was readily available on the market, the technology and competition. The manner of new entrants arrival made data readily accessible. Finally, the financial data available made a count of new competitors and their prospective capabilities relatively easy to assess.

### *Information Available*

The fact of rapid growth in the hard disk industry had made this an industry of interest to the providers of data. Market data were collected by such organizations as Dataquest, IDC, Venture Development Corporation and DISK TREND, Inc. These organizations provided extensive analysis of the market and the technology, including lists of existing and potential competitors. Technological data were readily available through a variety of industry and non-industry sources with magazines for general readership such as *High Technology* providing extensive overviews. *Computer Systems News* and *Mini-Micro Systems* provided entire issues profiling the markets, technology and competitors.

### *New Entrant Announcements*

Almost every issue of the major trade publications provided announcements of new products and new companies. The battle for financing became a battle of public relations experts as new firms announced product capabilities as a preemptive strategy and as a device to gain financial market recognition. These announcements often included technical specifications, estimated development dates, customer letters of intent and other data of great use in analysis of the bets outlined previously.

### *Financial Data*

By December, 1982, at least seven firms in the industry had made 12 public offerings of securities. Thus, considerable financial data were available directly from the public record. Even more valuable were the data collected by *Venture Economics*. This firm tracks all investments by venture capital firms. Thus it was possible to identify the 89 placements in 43 different companies which had been made. The amount of money available and the number of independent technological new ventures was readily apparent. Data such as those collected by *Venture Economics* are interesting from an historical perspective: they are critical in assessing the future course of an industry.

It is also interesting to note that venture capitalists had a potentially invaluable source of data—the torrent of business plans for entrants or participants in the disk drive and related (supplier, OEM) markets. Venture capitalists also often had simultaneous investments in one or more participants in the technological chain ranging from suppliers to drive manufacturers to computer systems builders.

### *Valuation Economics*

Some simple calculations in mid 1983 would have revealed the absurdity of valuation levels attained by the industry participants. To illustrate, if one assumes that Jim Porter's OEM sales forecasts for 1983–1987 are correct, that industry sales grow at 15% per year for the

next five years (1988–1992) and 10% per year for the following 20 years, that net margins are 10%, and that net fixed assets are 80% of sales, then the free cash flows generated by the industry can be calculated. In turn, these cash flows can be discounted to the present and compared with the valuation levels assigned in the public markets. Assuming a terminal value in year 30 equal to net book value, the present values of the projected cash flows at different discount rates are listed below:

Discount rate	Present value
10%	\$5.3 billion
12%	\$2.5 billion
18%	\$0

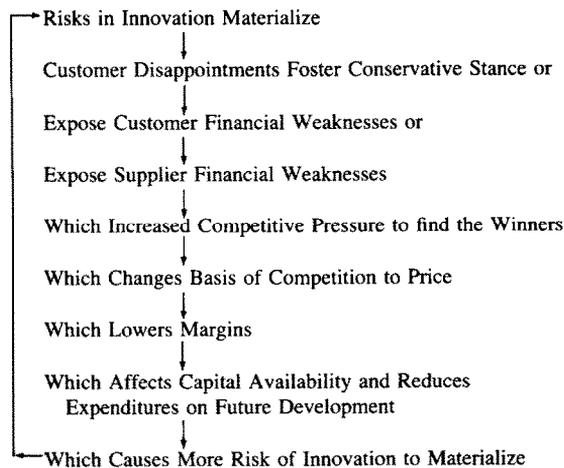
The reader can assess the reasonableness of these assumptions but should keep in mind two factors: 1) the profitability assumption is very generous considering the existence of over 70 competitors, and 2) the values calculated above pertain to the entire OEM disk drive industry, not just the 12 companies assigned a value of \$5.4 billion in mid-1983.

These data, taken as a whole, indicated the extreme risk in the bets being placed. The data suggested that while the individual bets might have reasonable probability of paying off, rational analysis clearly revealed that there was an extremely low probability for any individual firm succeeding considering that favorable outcomes on all bets was a prerequisite for success. A profitable strategy would have been to sell short a portfolio comprised of the stocks of *all* public disk drive companies knowing full well that a few companies would prosper, while most valuations would collapse under the weight of ruinous competition.

Yet, as late as the Fall of 1983, venture capitalists and stock market investors continued to pour money into the disk drive industry.

## IMPLICATIONS

Instead of the chain of success identified previously, there was a chain of failure:



The implications for the industry of this chain are obvious. It is interesting to note the important role of the capital markets in the chain. The availability of external capital served as one of the major precipitating elements both for the growth and for the downward spiral. Moreover, problems in the supply of capital affected disk drive users (OEMs) and disk drive suppliers, exacerbating the financial woes of the disk drive manufacturers themselves.

When the data shown in the exhibits are examined, it seems clear that those in the private and public capital markets had the best vantage point to anticipate:

- the emergence of numerous well-financed competitors;
- the existence of multiple competing technologies;
- the absolute requirement for continuing R&D expenditures; and
- the need for external capital to fund working capital, plant and equipment which could not be generated internally during periods of rapid growth.<sup>4</sup>

The professional investors did not serve the function of policing the capital markets. In fact, they continued to pour money into the industry well after the game should have been finished.

This capital market myopia may prove to be costly for both early and later players. From a national policy point of view it may prove costly as well. Initiatives may well be abandoned which might have provided the basis for improved national competitiveness. The industry has been sufficiently decimated to open the doors to foreign competition without credible threat of competitive retaliation. Moreover, the havoc wreaked in the capital markets may make it far harder for companies to raise money on acceptable terms in the future.

It is clear that massive industry restructuring will occur. Some major mergers have already been announced. Failures are being announced weekly. The returns to investors will be positive if and only if they can avoid becoming as myopically pessimistic as they were myopically optimistic. In late 1984, some of the public disk drive companies were trading at prices below net working capital per share.

## SUMMARY

The process of industry analysis described in this paper can be applied in many settings. All industry participants must focus first on the prospects for the industry. How large will it be? How profitable will it be? What will the path to maturity look like? Then, analysis of the prospects for individual players can be assessed. Ultimately, the effects of decisions at the individual company level *must be reconciled* with the aggregate industry view. Had this process been applied in the Winchester disk drive industry, the carnage would have been far less severe.

The lessons from the disk drive industry appear to have broad applicability in other industries ranging from biotechnology to integrated software to pizza parlor theaters. Investors who invest both their money and their sweat can benefit substantially from the kind of financial, strategic, and competitive analysis which has been outlined here.

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<sup>4</sup>For every \$1.00 of sales, disk drive companies needed approximately \$0.80 in fixed assets and working capital. To sustain high rates of growth with normal profitability levels necessitates heavy reliance on outside capital. Low profits or losses combined with rapid growth creates an untenable situation.

In this information age, a great deal of timely, relevant data are available. Wise investors accept consensus conclusion at their peril. Good decision making requires independent judgment. In essence, capital market myopia is a treatable disease.

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While DISK/TREND, Inc. and Venture Economics graciously supplied data for this article, responsibility resides with the authors for the analysis and conclusions.

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