

Winning the Competitive Edge in the DRAM Market:
A System Dynamics Analysis
by

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ABSTRACT

A system dynamics model is built to examine the global DRAM market. Two stages of DRAM development - commoditization and market conversion - are discussed in detail. The one-generation model includes the price, demand, financial, production, capacity, market, and sales sectors. The technology sector is built into the two-generation model.

There are three firms in this model - Firm Korea, Firm USA, and Firm Japan. Each firm has the same structure. One can examine the effects of a particular firm policy by changing the parameter values of the related decision variables. The model can also be aggregated to test the effect of long-term government policies on the global DRAM market.

The results from the model simulations and market analyses have important policy implications for both corporate and government policy makers.

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Chapter 1

Introduction

“I have been covering the semiconductor industry for about 20 years now. From what I've seen, there is much greater emphasis on the end-equipment markets [for semiconductors] and a lack of focus on the analysis of the industry's internal workings -- the manufacturing processes, the inventory cycles, the concept of yield, and all the individual things that contribute to making money in the semiconductor business.”

-- Thomas Kurlak
First VP, Merrill Lynch

1.1 Thesis Overview

Since the introduction of the first Dynamic Random Access Memory (DRAM) product in 1970, the DRAM market has evolved into one of the fastest growing segments of the global semiconductor industry. Its evolution over the past thirty years has witnessed an intriguing interplay of governments, industries and firms across the Pacific. Today, this strategic business remains highly competitive and volatile. Its ephemeral market dynamics challenge both government and corporate decision makers.

The players involved in the DRAM market can be grouped into three broad categories: the producers, the customers, and relevant government policy-makers. Each group has its own stake in the business. For the DRAM producers, the “good old days” notwithstanding, the market has proven to be one of the most ruthless examples of the “survival-of-the-fittest” Darwinism. Firms that fail to meet the competitive challenge,

both technological and financial, can disappear overnight. The main challenge facing the DRAM producers is therefore how to remain competitive in this highly volatile market.

The DRAM buyers, on the other hand, are more concerned with price fluctuations which can incur huge losses. A shortage of supply may even impede their own operations. Their priority is to understand why prices fluctuate and how to cope with price fluctuations. The latter is dependent on a thorough understanding of the former. Industrial policy-makers, in the meantime, have their own interest in the business. Besides its strategic position in the semiconductor industry, DRAM is often considered an “easy” industrial target for developing countries in comparison to its design-rich cousins such as microprocessors. This is largely due to the relative simplicity of the DRAM technology. The high volatility of the global DRAM market, however, threatens the survival of any premature entry. Their goal is to develop policies that will help establish domestic DRAM firms that are internationally competitive. For governments that are willing to intervene with the high volatility of the DRAM market, policy measures that can stabilize the prices are also of interests.

This thesis, therefore, attempts to answer the questions facing the producers, the buyers, and the Governments by analyzing the competitive forces in the global DRAM market. The first part of the thesis adopts an historical approach. It lays out the development of the DRAM business. In particular, it examines various government programs, corporate strategies and broader economic conditions that have affected DRAM market dynamics. The literature and history review lays the foundation for the main body of the thesis that follows.

The second part of the thesis is a system dynamics model that attempts to quantify the forces that shape the current DRAM market. It adopts the modern system dynamics modeling approach which consists of problem definition using reference modes, causal loop diagrams, and the actual model with stocks and flows. The model is developed within Vensim DSS¹. It includes two generations of DRAM products and three producers. The dynamics of a multi-generation and competitive (more than three producers) market can be inferred through analogy. The purpose of the model is to identify basic dynamics. It is not intended to produce point predictions of the market.

The last part of the thesis discusses the model's simulation results. It examines the factors that change market dynamics. The factors reflect the main players in the market: producers with their production and marketing strategies, customers with their demand sensitivity, and government sector with its control over technological and financial resources. Controlled simulations will be conducted accordingly. Finally, an interesting question to keep in mind: Will DRAM's close cousin – microprocessors – evolve with similar dynamics? More generally, under what condition will a high-tech industry repeat DRAM experience? The thesis concludes with policy recommendations for both government and corporate policy makers.

1.2 Literature and Data Sources

A large amount of research has been conducted on the semiconductor industry. There is, however, relatively little done on the subject of DRAM *per se*. This might be

¹ Vensim® Version 1.62, Ventana Systems, Inc.

because DRAM is not an end product. It is merely a memory device that is used in various applications, the biggest of which happens to be personal computers (PC). As a result, it was virtually unheard of in the United States until the 1986-88 DRAM crisis during which people began to realize its strategic importance. Even today, many academic writers consider DRAM as a small part of the semiconductor industry that does not deserve special treatment.

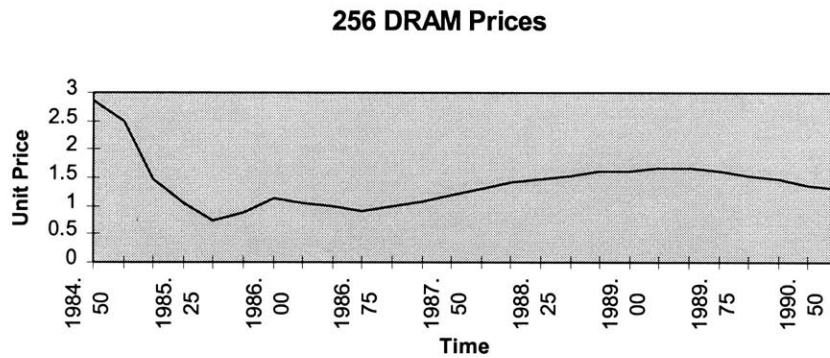


Figure 1.1 256 DRAM Price Hikes

In fact, DRAM is a strategic industry in itself. A sustained DRAM supply is vital to the healthy operation of the original equipment manufacturers (OEMs). A DRAM shortage and price hikes, for example, can create turmoil in the U.S. computer market. In the meantime, the DRAM business comprises a good opportunity for countries that aim to develop their own high-tech industry. While jumping into design-rich high-tech products such as microprocessors is an unrealistic goal because of technological constraints, DRAM's relatively simple design and volume production make it an ideal starting point. Its risky nature also makes government an integral part of the effort, which is more politically acceptable to many developing nations. In retrospect, DRAM played an important role in the development of the Japanese and Korean semiconductor industry.

Taiwan is currently trying to emulate this experience, although they still have a long way to go.

Fortunately, there is a vast amount of data and press coverage available. In his 1995 M.S. thesis on silicon cycles, Kenneth VanBree provided a comprehensive list of data sources on the semiconductor industry. The U.S. Department of Commerce, the United Nations, the Semiconductor Industry Association (SIA) and a handful of U.S. consulting firms including VLSI Research Inc., Dataquest, and Integrated Circuits Engineering (ICE) are all excellent sources of data.²

Detailed analysis of the DRAM industry can be found in many business, computer and policy-related journals. Among them, the *Electronic Buyers' News* and the *Electronic Engineering Times* offer the most up-to-date and in-depth analyses. For a complete listing of the journals, please refer to the Bibliography.

² [VanBree, 1995], p.15-6

Chapter 2

DRAM Market Review

2.1 An Evolving New Frontier

2.1.1 *The American Monopoly*

The modern semiconductor industry developed rapidly after World War Two. In 1962, the first integrated circuit (IC) using the new metal-oxide semiconductor (MOS) technology was invented. The two major MOS product areas are microprocessors and DRAMs. A DRAM is a particular kind of memory circuit which requires that stored data be continuously refreshed. The storage capacity of the memory device is measured in 1.024×10^3 units called kilobits or K, and later in megabit (1.024×10^6) or gigabit (1.024×10^9) units. Figure 2.1.1 illustrates how DRAMs fit into a Printed Circuit Board (PCB). The PCB will then fit into a Single In-Line Memory Module (SIMM) socket on a computer's system board.

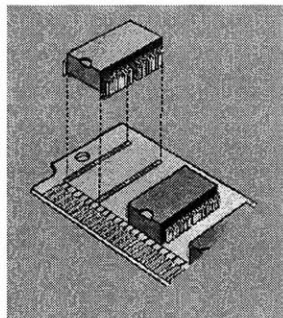


Figure 2.1.1 DRAM and SIMM³

³ The Ultimate Memory Guide, KTC

In late 1970, both Intel and Advanced Memory Systems (AMS) introduced the 1K DRAM to the market. Intel's design became the industry standard. Its 1K DRAM, serialized 1103, was built with the company's new p-channel silicon-gate MOS technology. By the end of 1971, the 1103 was the world's top-selling semiconductor device. In 1972, it was being used by 14 out of 18 mainframe computer manufacturers in the United States, Europe, and Japan. More than 35 million 1103s were shipped.⁴ Intel became the first successful mover in the DRAM market

Three years later, Intel introduced the first 4K DRAM, and captured more than 80% of the market by 1973.⁵ Being the technology leader and the sole producer of the DRAM, Intel enjoyed several years of monopoly privilege in the 1K and 4K market. In late 1973, Mostek – a new IC company founded in 1969 in Carrollton, Texas – entered the 4K DRAM market. It invented the multiplexed RAS/CAS⁶ style DRAM. The user-friendly design was welcomed by many of the DRAM buyers, and it became the industry standard. Mostek began to seize market share away from Intel. Competition soon intensified. A number of U.S. chip makers including National Semiconductor, Advanced Micro Devices (AMD), Motorola, and Texas Instruments joined the race at the 4-kilobit level. The 4K DRAM market became very competitive.

The first 16K DRAM made its appearance in 1976. Intel's design won the industry standard. Besides Intel, Mostek and Texas Instruments also led the entry into

⁴ [Iversen, 1991]

⁵ [Burgelman, 1996], p192

⁶ RAS stands for Row Address Strobe, and CAS for Column Address Strobe.

the new market. In 1976, Intel's 16K market share was 35%.⁷ The competitive challenge from Mostek and others continued throughout the late 1970s. By 1979, Intel's market share in the standard 16K DRAMs was less than 5%.⁸ Its monopoly position was lost for good.

The use of the new MOS circuits in computer memories spawned the growth of a new mass market for IC devices. In 1971, the U.S. market for digital semiconductor memory was approximately \$60 million. Memory sales exploded to \$500 million in 1976, and \$1,290 million in 1979.⁹ The United States was the monopoly producer of DRAMs for the first half of the 70s. The industry at its early stage of development adopted an unofficial industry standard. The firm whose product became the industry standard had a significant competitive advantage over others. The profit margin was high given the strong demand and rapid decreases in production costs.

The extraordinary growth of the DRAM market attracted foreign attention and invited foreign entry. DRAM soon became the target of the Japanese national industrial strategy.

2.1.2 The Japanese Era

The Japanese made their first appearance on the DRAM market in 1976. NEC, Fujitsu and Hitachi were the first Japanese companies that entered the memory market. They, along with other Japanese firms that came later, proved to be formidable

⁷ [Burgelman, 1996], p192

⁸ Ibid., p. 193

⁹ [Charles River Associates, 1980], p.4-23

competition for the Americans. The Japanese vendors' share of the 16K DRAM business jumped from about 4% in 1975 to nearly 40% by 1980.¹⁰

What contributed to Japan's rapid success? Many believed that the Japanese firms, assisted by their government, were able to offer lower prices than their U.S. competitors. In 1980, however, Hewlett-Packard (HP) released a report that shocked the U.S. industries. Comparing the quality and reliability of 4K and 16K DRAMs procured from the Japanese and the U.S. manufacturers, HP concluded that the Japanese DRAMs performed "consistently better" by a large margin. The report contradicted the widely held view that Japan's rise was solely due to aggressive pricing strategy.

The Japanese pressed their technological advantage, and quickened their pace to become the world's biggest DRAM producer. In 1979, Fujitsu introduced the first 64K DRAM that became the industry standard. Following this remarkable success, Fujitsu and Hitachi together pioneered the entry into the standard 256K DRAM market three years later, and again captured a premium market share. In 1982, Japan surpassed the U.S. as the world's biggest DRAM supplier. By 1987, only two of the major U.S. firms – Micron Technology and Texas Instruments – stayed in the merchant DRAM business, and they accounted for 15% of market share. (Table 2.1.1)

Rank	Company	Revenue (000)	Market Share
1	Toshiba	\$452,755	17.3%
2	NEC	\$368,800	14.1
3	Mitsubishi	\$313,780	12.0
4	Texas Instruments	\$286,575	11.0
5	Hitachi	\$278,662	10.7

¹⁰ [Iverson, 1991]

6	Fujitsu	\$240,431	9.2
7	Samsung	\$186,275	7.1
8	Oki Electric	\$122,152	4.7
9	Micron Technology	\$109,743	4.2
10	Sharp	\$47,190	1.8

Table 2.1.1 1987 DRAM Market Share (Source: Dataquest)

Among the firms that left the commercial market were familiar names: AMD, AMI, Fairchild, Intel, ITT, National Semiconductor, Motorola ¹¹, and Zilog. Mostek, which once employed 10,000 people, disappeared almost overnight.¹² One of the main contributing factors to this phenomenal mass exit was the immense profit loss experienced by the American firms during the DRAM bust of 1984-1985. Their market share plummeted as the Japanese took control of the market.

The rise of the Japanese and the decline of the Americans in the DRAM business surprised many. How did the Japanese take control away from the Americans? Why did companies like Mostek that had successfully competed with Intel lose so miserably in face of the Japanese challenge? Joe Parkinson, President of Micron Technology, remarked bitterly in a 1986 New York Times interview: “ We’ve got a problem in this country, and high technology is no exception. We have this idea that as soon as the Japanese target an industry, you are automatically dumber than a post to be in it.”¹³ His words vividly illustrated the frustrations of the U.S. semiconductor companies.

¹¹ Motorola still produced DRAMs, but the production was limited to its internal usage.

¹² [Appleton, 1993]

¹³ [Sanger, 1986]

2.1.3 The Korean Surge

While the American companies were wincing at Japan's apparent "invincibility", a newcomer arrived on the DRAM scene and began to challenge Japan's supremacy. To many people's surprise, the Japanese turned out to be the loser in the new race. Their competitive advantage was quickly reduced. By the end of the 80s, Japan had lost much of its monopoly position for good.

The new member of the DRAM family was South Korea. In an effort to enter high value-added and capital-intensive industries, three South Korean industrial *chaebols*¹⁴ – Samsung, Hyundai, and Goldstar – started their DRAM production at the 64K level in the mid-80s. The Korean market share in 1986 was 4%, and rose to 17% in 1990.¹⁵

At first sight Korea's gaining of market share may not appear as "miraculous" as the rise of Japan ten years ago. What has happened over the course of the mid 80s through the mid 90s is a continual increase of market power at the expense of the Japanese. None of the top Japanese producers was driven out of the market. Since Samsung and its fellow producers made it to the Top 15 DRAM Producers Chart, most Japanese companies have managed to stay on the chart. What is different is the actual ranking among them. (Table 2.1.2) Samsung climbed from number seven in 1987 to number one in 1995 – its market share rose from 7.1% in 1987 [Table 2.1.1] to about 15% in 1995. The other two Korean companies – Hyundai and LG Semicon (formerly

¹⁴ The word *chaebol* means "giant conglomerate" in Korean.

¹⁵ [Dataquest 1991]

known as Goldstar) – also successfully made it to the top 10 list, leaving all of the American firms behind.

Korea controls about 40% of the DRAM market at present.¹⁶ It is as powerful a player as Japan. Korea now leads the world in the development of 1Gb DRAM. In some niche market segments, it has absolute dominance. What is significant about the rise of the Koreans, ironically, is that there is nothing significantly different about the Korean firms. They adopted the same strategies as their Japanese neighbors did – aggressive investment, aggressive production and aggressive pricing. They had good timings and all kinds of support on their side, and they were committed. The Japanese, on the other hand, were severely constrained by their prolonged economic recession at home.

Rank	Company	Sales (Millions)	Market Share (%)
1	Samsung	\$6,381	15.63 ¹⁷
2	NEC	\$4,695	11.50
3	Hitachi	\$4,264	10.44
4	Toshiba	\$3,717	9.10
5	Hyundai	\$3,471	8.50
6	LG Semicon	\$3,088	7.56
7	Texas Instruments	\$2,636	6.46
8	Micron	\$2,551	6.25
9	Mitsubishi	\$2,061	5.05
10	IBM	\$1,993	4.88
Total		\$34,875	85.37

Table 2.1.2 1995 DRAM Market Share (Source: In-Stat, Inc.)

During this period, the United States has been able to cling to its sliver of the market. Interestingly enough, the Koreans did not drive the U.S. producers out of the market. In 1995, the U.S. controlled about 20% of the DRAM business, which was an

improvement over its 15% share in 1987. The good performance of the U.S. chip-makers indicates the success of their effort to improve competitiveness through cost-reduction and aggressive marketing.

While it can be argued that the Japanese and the Americans have quite different systems which have led to very different outcomes, Korea's success story poses some intriguing new questions. How viable is the Japanese system in sustaining growth over the long run? Aggressive pricing, for example, severely hurts corporate profit unless it is accompanied by aggressive cost cutting or a monopoly position. Should any government intervene through financial and technological means? What are the fundamental forces that drive a company's competitiveness in the DRAM business? The next section will attempt to answer these questions.

2.2 Market Dynamism ¹⁸

While it is impossible to lay out all the dynamic forces that are at work in the DRAM market, it is important to focus on the main dynamics. The discussion is divided into three parts – the DRAM industry, the role of the government, and corporate strategies. A comparative study of the Japanese, U.S., and Korean DRAM businesses will shed light on the subject.

¹⁶ [Dataquest, 1997]

¹⁷ Dataquest's estimate is 14.8%.

¹⁸ This section is largely based on the discussions with managers from Hewlett-Packard from September 1996 to April 1997.

2.2.1 The DRAM Industry

The DRAM industry is one of the fastest growing and exciting industries in the twentieth-century global economy. Its *growth rate* has been phenomenal. In 1987, total DRAM industry revenues were about \$2.6 billion.¹⁹ The global sales skyrocketed to \$9.2 billion in 1989.²⁰ In 1995, a record high of \$40.7 billion in sales was achieved, up from \$23.4 billion a year earlier.²¹ In less than eight years, the industry grew by more than 1400% in sales revenue. The average growth rate during this period was 31.6%. The growth potential for the DRAM industry remains strong toward the end of the century. Dataquest, a leading IC consulting firm, predicted that sales will reach \$100 billion by the end of the century.²²

From cameras and televisions, to computers and telecommunication systems, the vast majority of electronic devices are incorporating more and more intelligence. DRAM is the fuel that will feed that intelligence. The computer industry is so far the largest *end-use consumer* of the DRAMs. Non-computer applications are also growing very rapidly. A normal TV set, for example, does not have a memory need, but a high-definition television (HDTV) may need as much as 32 Megabits of DRAM for good performance.²³ As of 1995, non-computer DRAM applications accounted for 33% of total consumption, and are expected to grow to 39% by the year 2000.²⁴

¹⁹ [Dataquest, 1988]

²⁰ [DeYoung, 1990]

²¹ *Electronic Buyers' News*, March 4, 1996

²² [Dataquest, 1997], <http://stonewall.dataquest.com/irc/press/ir-n9544.html>

²³ [Kane, 1989]

²⁴ [Garber, 1996]

DRAM itself is an important *technology driver*, both for process and end-product technologies. On the one hand, DRAM's simple structure makes it an ideal product with which to test and implement advanced manufacturing process technologies. High volume production, on the other hand, allows for the long runs needed to refine production methods and quality-control mechanisms. As a result, DRAM can play an important role in helping to develop a domestic semiconductor industry. In 1975, Japan's Ministry of International Trade and Industry, known as MITI, targeted DRAM as a strategic technology, and devoted tremendous resources to its development. It has turned out to be one of the most influential and far-reaching industrial policies undertaken by MITI.

DRAM is often considered as a "*commodity*" chip – in contrast to the "design-rich" chips such as microprocessors and micro-controllers. The reason is that DRAMs have a relatively simple architecture, and are quite easy to design.²⁵ The technology to produce state-of-the-art DRAM including chip-design and die-shrinking can be obtained from others through licensing or other forms of technology transfers.²⁶ Even though the initial acquiring of the technology may be costly and difficult, technology alone does not constitute a strong barrier to entry.

Choi (1996) pointed out that the *time lag* between the development of the technology and actual mass production in the DRAM industry makes the catching-up process of the late-comers much easier. The leading firms have to delay the timing of mass production for the new generation DRAM until the market transition is well in

²⁵ The emphasis here is on relativity. DRAM's design is considered simple only when compared with design-rich chips such as microprocessors. The complexity of its design technology should not be ignored.

progress. On average, there is a two- or three-year lag between the initial development of the technology and the volume production. [See Table 2.1.2]

		64K	256K	1M	4M	16M	1G
Development	U.S. & Japan	1977	1980	1983	1986	1987	1997
	Korea	1983	1984	1986	1988	1990	1996
	Gaps	6	4	3	2	3	-1
Mass Production	U.S. & Japan	1980	1982	1985	1989	1992	
	Korea	1984	1985	1987	1990	1992	
	Gap	4	3	3	1	0	

Table 2.1.3 DRAM Technology & Production Gaps by Korean Firms
(Source: Choi, 1996)

Like other commodities, DRAMs are usually sold in large quantities depending on the buyers' memory requirement. The *scope of purchase* can reach several million units. Manufacturers compete on their ability to climb up the learning curve and cut production costs. The DRAM density quadruples every two to three years. Price per bit drops as memory density increases. DRAM price, for instance, fell from about 1 cent per bit in 1970 to 0.05 cent per bit in 1979. For each doubling of the cumulative output, the cost per electronic function declined on the average by 28 percent.²⁷ The volume increase in production leads to lower cost per bit, which leads to lower price and surges in demand, and further increases production.

The *competition* in the business is fierce and sometimes deadly. Huge capital investment leaves managers little choice but to engage in head-on competitions with one another. An increase in market share is often accompanied by huge losses in profits, as

²⁶ Some Korean firms, for instance, have allegedly developed their DRAM technology through illegal reverse-engineering.

was the case with the Japanese in the early 80s. Profit margin erodes quickly when the mainstream product market matures.

The DRAM business, on the other hand, resembles a high-tech market in its *cyclical and risky* nature. A technological lead – the ability to bring production for the new generation DRAM in volume – can bring in millions of dollars of profit. Continuous capital investments are necessary to remain competitive in the DRAM market. Such investments include plans to build new capacity, which can cost millions of dollars. The time lag between investment and return is quite long. Since DRAM is not an end product by itself, it is vulnerable to the swings in its end-use markets – the PC industry in particular.

Various market distortions exist in the DRAM business. Technological and financial aid from governments of Japan and Korea to their DRAM manufacturers make it hard for others to have a fair competition.²⁸ Market access to some foreign markets including Japan and Korea is hard to obtain.

DRAM consumers can be grouped into three categories – the high-end users, the mainstream users, and the low-end users.²⁹ The high-end users include manufacturers of work-stations (WS) and servers. They constitute less than 10% of the market. Their primary concern is technology and they are not price-sensitive. The high-end users fuel the technology innovations in the DRAM industry. They provide the necessary financial and market resources for the fragile new generation DRAM market to develop. The

²⁷ [Borras, 1988], p. 83

²⁸ More on this in the next section.

²⁹ This part is heavily drawn from discussions with Greg Jacobus, a senior consultant for Hewlett-Packard.

mainstream DRAM buyers are the PC makers. They occupy around 70% of the market. They are more concerned with availability and prices. Given the competitive nature of the PC industry, they cannot afford to pay a higher price on a per unit basis than their competitors. In the meantime, guaranteed availability is also essential for their healthy operation. A better knowledge of the price-sensitiveness of the mainstream DRAM buyers is essential for the understanding of many DRAM market dynamics such as the dumping practice undertaken by the Japanese in the 80s. The last group is the low-end buyers, earlier defined as the non-computer applications. They include a variety of electronics products such as printers and scanners. Their memory needs are usually low-density. Like the mainstream PC makers, the low-end users are highly price-elastic.

2.2.2 Government Intervention

All three governments intervened in the industry, but employed different approaches with very different outcomes. First of all, the *goals* were quite different. The Korean and Japanese government were concerned with building a competitive domestic high-tech industry. This was part of their national industrial strategy to catch up with the West. Their goal was to help their semiconductor firms compete in the international market. The U.S. government, on the other hand, was more interested in maintaining the technological leadership of the U.S. military. Very little consideration was given to domestic producers. We need to keep in mind this difference in objectives when examining the policies undertaken by these government.

On July 15, 1975, the Japanese Ministry of International Trade and Industry (MITI) and Japan's Nippon Telegraph and Telephone (NTT) agreed to initiate a joint

program aiming at developing the new generation of semiconductor technology – Very Large Scale Integration (VLSI). The four-year project began in 1976, and the funding amounted to \$250 - \$350 million.³⁰ This was part of a Japan's conscious national strategy of creating a competitive advantage in technology-intensive and knowledge-intensive industries. A large proportion of the project's funding was spent on purchasing the most advanced manufacturing and test equipment from the U.S. The modernization of the production capacity freed major Japanese firms to apply resources to the development of the high value-added ICs. VLSI also passed hundreds of patents down to the participating firms, enhancing their technological position.

Besides VLSI and other government programs (e.g. the Fifth Generation Computer Project) to promote the semiconductor industry, the Japanese government made a continuous effort to protect its domestic semiconductor industry. The strongest evidence is the limited foreign access to Japan's domestic market. From 1973 to 1986, the foreign share of the Japanese semiconductor market constantly hovered at a 10% level. In 1985, for instance, the U.S. share of the Japanese market was 8.5% versus a U.S. worldwide market share outside Japan of more than 70%.³¹ MITI also helped provide long-term, free or low-cost loans to the Japanese firms. These financial packages gave the Japanese DRAM makers a strong incentive to invest in their capacity and R&D. A research study by Chase Manhattan Bank in 1980 found that the U.S. firms were at a

³⁰ [Langlois, 1988]

³¹ [SIA Status Report, 1996], p.9

significant disadvantage versus their international competitors, especially the Japanese, in obtaining necessary capital.³²

The presence of the U.S. government was less prominent. Its role in the development of DRAM in the 70s was minimal. The key breakthroughs in most of the American firms were financed by private funds. With the erosion of America's competitive position, pressure for the U.S. government to intervene escalated. Wary of Japan's takeover of the strategic semiconductor industry, the Defense Department was first to take action. It launched the Very High Speed Integrated Circuit Project (VHSIC) in 1980. This project was often contrasted with MITI's programs since both were industrial cooperative research efforts. This ten-year \$900 million program was fundamentally different from that of the Japanese government. The most significant difference of all is that the sharing of technology was restricted to qualified defense users, all of which were the suppliers of the Defense Department. Given the program's focus on national security, strong control mechanisms were established to prevent unwarranted dissemination. The project did little in helping the commercial competitive position of the U.S. industry. As Richard Samuels concluded in 1994:

“In fact, U.S. private institutions seemed no better suited than government arsenals to facilitate the inter-diffusion of technology. The successful application of dual-use technology requires more than private ownership. It requires a strategic commitment to the diffusion of innovation, and it requires an institutional, as well as ideological, infrastructure to nurture it.”³³

³² Ibid., p.8

³³ [Samuels, 1994]

Such an institutional infrastructure was absent in the U.S. It is worth noting, however, that the U.S. government played an important role in the trade negotiations with Japan and Korea respectively. By 1984, it was evident that the Japanese were dumping – pricing below production cost – DRAMs in the U.S. market. Many U.S. firms, including Micron Technology, filed trade complaints against the Japanese DRAM makers for unfair competition. In 1986, the Department of Commerce concluded that the Japanese were selling at prices far below the cost of production in the U.S. market, by a margin of 65%.

³⁴ After lengthy negotiations, a bilateral Semiconductor Trade Agreement was signed by both governments in an effort to eliminate dumping and improve market access conditions in Japan. Whether the Trade Agreement achieved its goals or not is highly controversial. The Agreement was intended to assist the U.S. firms to re-enter the DRAM market. Dumping by the Japanese gradually ceased, and prices bounced back. The expected re-entry, unfortunately, did not happen. The main explanation is that re-entry was expensive, technologically risky, and required long-term commitment. In 1988, it was estimated that the cost of building a DRAM factory approached \$200 million per year, not including the required design and process specialists to produce a competitive product.³⁵ At that time, it took 18 to 24 months to produce wafers with satisfactory yields.³⁶ The U.S. firms were simply not willing to bear the losses of another round of price war with the Japanese.

³⁴ [SIA, 1996] The number cited in the original SIA report was 188%. It is obvious that any number beyond one is mathematically meaningless. The only plausible explanation is that the authors made a common mistake when calculating margins – they used the selling price instead of the production costs as the denominator. Corrected for this error, the margin turns out to be 65%.

³⁵ [Procassini, 1988]

³⁶ Ibid.

With the reluctance of the U.S. memory makers to re-enter the DRAM market, the Trade Agreement achieved an unexpected result – it created an environment conducive to the formation of a Japanese cartel that were able to charge high prices.³⁷ After the signing of the Trade Agreement, MITI imposed strict production control over the Japanese DRAM makers. This production control resembles the policing force in an oligopoly situation – anyone who diverges from the production quota in an oligopoly will be punished. DRAM supply dropped significantly as a result. In the meantime, the Trade agreement put a lower bound on price. Both production and price controls were anti-competitive measures. Instead of returning to the competitive equilibrium price, therefore, the DRAM prices skyrocketed and a severe supply shortage followed immediately.

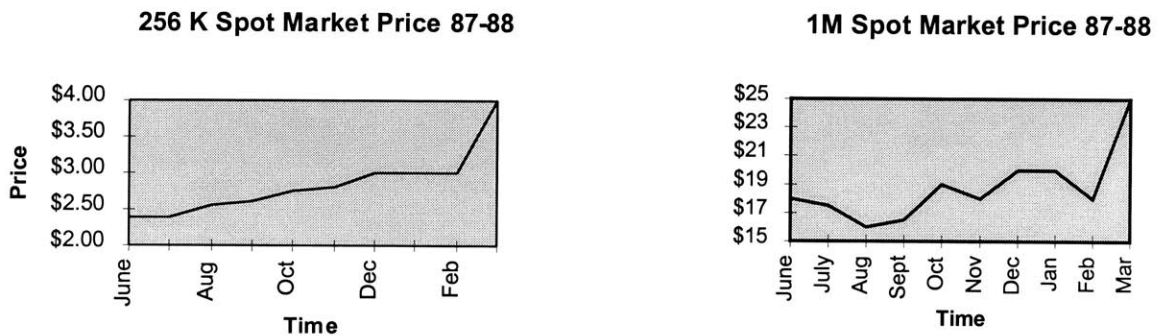


Figure 2.2.1 256K and 1M Spot Market Price (June 87 - March 88)³⁸

Figure 2.2.1 shows the prices for 256K and 1M DRAMs from June 87 to March 88 respectively. In the case of 256K DRAM, the price went up by 67% in less than nine months.

³⁷ [Pollack, Andrew, 1988]

It is important to realize that the Trade Pact alone would not produce a seller's market. Many factors contributed to the supply shortage and the "cartelization" phenomenon: MITI's effort to limit production as a result of the trade agreement; Japan's control of the DRAM market (around 80% of the market share); rising memory demand; and production problems that arose from the shift to the new generation of DRAM.³⁹

What happened after the signing of the second U.S.-Japan Trade Agreement further illustrated this point. In June 1991, the Office of the U.S. Trade Representative signed a bilateral semiconductor arrangement with the Japanese government limiting Japan's pricing flexibility. Not even a ripple of price change showed up in the marketplace. The Japanese continued to suffer serious over-capacity problems. The Korean chip makers became the biggest beneficiaries since they were not included in the price control scheme. Samsung continued to sell the DRAMs at a lower price than the prevailing market price in order to gain market share.⁴⁰

In sum, a Trade Agreement alone is not sufficient to induce an anti-competitive environment. Only when coupled with certain market conditions will it suppress competition. Government, on the other hand, can play an active role in improving the competitiveness of its domestic firms by anti-competitive means.

The Korean government has played a role similar to that of the Japanese government. They provide financial incentives, technology, and other necessary market conditions for their domestic industry to mature. The Korean market, for example, is

³⁸ Dataquest, 1988

³⁹ More discussions on generational capacity conversion will follow.

almost as closed as the Japanese was. In the meantime, the Korean government often intervenes with firm-level decision making when it deems necessary. In February of 1997, it forced the Korean producers to cut production in an effort to raise the 16M DRAM price so that a healthy conversion to the 64M DRAM will be achieved. Many, however, maintain that the role of the Korean government was much less prominent than the Japanese.⁴¹ They believe that the *Chaebols*, or mother companies, shared most of the financial and technological risks. They do acknowledge, however, the fact that the Korean government has been very supportive of their domestic DRAM industry.

2.2.3 The Corporate Level

Firms in the DRAM business display considerable disparity in their investment, marketing, and product development strategies. In general, the U.S. firms are quite different from their Japanese and Korean competitors. For example, they are less aggressive in pricing and capacity building. The Koreans at their early stage of development adopted many of the corporate strategies created by the Japanese, and their corporate structure therefore resembles that of the Japanese firms.

First of all, there exists similarities and differences among the *investment patterns*. The DRAM business has an “inherent” cyclical nature, and many believe it is induced by the fact that managers are often too conservative to invest during a DRAM bust. The DRAM producers always postpone investment plans when the market is soft, and wait

⁴⁰ According to the *Electronic Buyer's News*, 1M DRAM market price was \$6.50 in April 1990. Samsung's price tag was two dollar less.

until there is significant improvement in the market condition. This kind of investment pattern can be understood in the context of the high-investment and high-risk nature of the DRAM industry. When DRAM demand picks up momentum, the market often responds with a supply shortage given the managers' conservative investment behavior. The DRAM firms then scramble to build up as much capacity as possible, usually disproportionately to their real share of the market. The motive behind it is an "insatiable" drive for market share – the more capacity one firm has, the more market it will have. Of course, it is not hard to note the pitfall of such reasoning – a firm will obtain extra market share from its capacity only when the market is in shortage and its competitors are falling behind in their capacity building. After a period of DRAM shortage, supply and demand gradually reach balance. The market gradually converts into a buyer's market as a result of the aggressive capital investment by the DRAM makers.

It is interesting to note that if a manager invests early enough, that is, during the DRAM bust, the firm will be able to offer a sustained supply when no one else is able to do so. It can easily earn a good return on its early investment. As pointed out by many HP managers, however, this is easier said than done. It is hard to justify a big capital investment project when the market is weak. Given the long time lag that exists between the initial investment and final production, an earlier than usual capital investment certainly will look bad on a performance evaluation form.⁴²

⁴¹ [Choi, 1996]

⁴² If government steps in with financial support, such counter-cyclical investment patterns become feasible. More discussions later.

On the firm level, the Japanese and Koreans are always more aggressive than the Americans. This is one of the main reasons why they perform so well in the DRAM market. Japan in the 70s had a very low interest rate. MITI, at this time, provided the Japanese semiconductor firms with low- or no-interest loans. The Japanese “Big-Five” – Hitachi, NEC, Mitsubishi, Fujitsu, and Toshiba – were all microelectronics giants that had enormous financial resources. Those companies thus were able to invest heavily. In some cases, they were even able to invest counter-cyclically, a practice that their American counterparts could not afford to undertake. In the case of Korea, a similar story can be told. The Korean government provided strong incentives, in terms of low-interest loans or subsidies, for the Korean firms to invest heavily. Furthermore, all three Korean firms are big industrial giants that are able to support the fledgling DRAM section. Heavy investment in the late 80s and early 90s played an important role in Korea’s rise in the DRAM market. During this period, Japan’s economy experienced a prolonged recession. Investment became a luxury for the Japanese. Therefore, their control of the DRAM market was significantly weakened.

Investment has always been very risky and expensive. Either the government steps in to help the firms out, or the firms themselves have to bear large losses. It is reported that the Korean government has put up more than half of the estimated \$360 million from 1988 to 1993 for the development of memory chips.⁴³ A 1992 research

⁴³ [Appleton, 1993]

report by Rajiv Haudhri, a Goldman Sachs analyst, estimated that from 1982 to 1992, the Japanese semiconductor “cash flow was negative to the tune of \$5 billion”.⁴⁴

Secondly, differences exist in *R&D* spending and the *learning-curve* phenomenon. The technology to produce DRAM is relatively easy to acquire, compared with other MOS products. Many Japanese and Korean firms entered the business without advanced semiconductor production technology. In fact, some – as in the case of Hyundai – had no previous experience in electronics at all. Various forms of technology transfers became an important factor of production. The Japanese firms learned a tremendous amount from the Americans. The Koreans, being the late-comer, learned from both Japan and the U.S. This learning process encompasses not only technological innovations but also managerial decision making. Table 2.2.1 lists some of the key technology transfers Samsung undertook from 1983 to 1991. Three main forms of technology transfers were technological information agreements, patent licensing agreements and technology service agreements. It should be noted that both strong financial backing and strong in-house engineering capabilities are required to obtain the technologies and utilize them in manufacturing.

Year	Partner	Agreement Type	Contents
83	Micron Technology	ABC*	64K & 256K DRAM
84	SSI (outpost)	ABE	256K DRAM
85	SSI (outpost)	AB	1M DRAM
87	Intel	C	DRAM Patents
88	Hitachi	C	64K & 256K DRAM
89	NCR	ABC	64K, 128K, 256K, 512K ROM
90	NEC	C	DRAM Products

⁴⁴ Ibid.

91	Mitsubishi	C	DRAM Patents
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Table 2.2.1 Technology Imports by Samsung ⁴⁵

*A: technological information agreement

B: technology service agreement

C: patent licensing agreement

E: others

In the early 80s, the Japanese focused on large-scale manufacturing, while the U.S. plans centered on high-technology design. With the capability to churn out commodity chips in huge volume, the Japanese firms came down the learning curve much faster. As a result, the Japanese were able to offer a much lower price and captured more and more market share from the Americans. ⁴⁶

Firms have different strategies concerning R&D spending. The so-called technology leaders – Samsung, Hitachi, NEC, and Toshiba – spend much of their R&D investment on product development and volume production to capture a big market share in the new generation DRAM market. The “followers” tend to spend more energy on process improvement and niche products. Micron Technology, for example, adopts a basic strategy of design and manufacturing. They shrink die sizes fast to allow a good profit margin. They crunch cycle times to change the product mix as fast as demand for different memory configurations changes. They make technologically competitive products with good quality.

It is sometimes hard to distinguish technology leaders and followers. Some technology leaders are also great process innovators. While being the paramount technology leader in the DRAM business, Samsung is also the most efficient and

⁴⁵ [Choi, 1996], p.60

diversified of all. In sum, the cost advantage is an important part of a firm's competitiveness in the DRAM business. It lays the foundation for important strategic decision making such as pricing. While production cost is often reduced dramatically as volume increases, process innovations are also necessary to produce a company-specific advantage.

The third strategic area concerns *aggressiveness in pricing*. The DRAM buyers can be loosely grouped into three categories. The biggest of all is the PC makers. Given the volatile nature of the PC business, they are highly price-sensitive. The low-end DRAM buyers – makers of printers, scanners, etc. – are also extremely price elastic. The only group that is very technology oriented is the work-stations and servers. They are the real technology driver in the DRAM business, but their presence is limited compared with the other two groups. As a result, pricing strategies play a vital role in a company's survival in the DRAM market.

In the late 70s and early 80s, the Japanese engaged in a series of aggressive pricing practices. Their market share soared. Most of the American firms were forced out of the market. Ten years later, the Koreans joined the race with a similar strategy. Samsung, along with Hyundai and LG Semicon, priced lower than average and captured a large market. It is the price-sensitive nature of the majority of DRAM buyers that makes this pricing scheme so effective.

Heavy investment and aggressive pricing are often called the success formula in the DRAM business. It should be noted that both are highly risky, and require strong

⁴⁶ There is also plenty of evidence that the Japanese practiced dumping during that period. Dumping alone,

financial backing. Aggressive pricing incurs huge losses in the industry. The firms engaging in such practices price below market, or sometimes below production cost. The intention is to drive the competitors out. The winners then charge a higher price once competition disappears. It is important to understand the risks involved. On the one hand, the firms that are aggressive usually incur a bigger loss than the passive ones. This is why Japan lost twice as much as the U.S. in the DRAM warfare in the early 80s. On the other hand, the DRAM market has become more competitive in nature. It is hard to form the kind of *de facto* cartel that the Japanese had in the 80s. No company or nation is powerful enough to repeat this. In fact, aggressive pricing creates all kinds of new problems, and its role has been severely limited.

The low price of 16M DRAMs, for example, is making the transition to the new generation (64M) extremely hard. The profit margin for the 16M has reached its bottom, and big DRAM leaders led by Samsung are pushing the conversion into the 64M. The problem, again, arises from the price-sensitive nature of the DRAM business. Unless price crossover (See Figure 2.2.3)– the price of 64M quadruples the price of 16M – takes place, a market transition is unlikely. Prematurely lowering prices on the higher density parts, however, is intrinsically dangerous. Forcing a market transition at too low a price means that those manufactures will not be able to profitably recoup sizable investments on the higher density device. The big DRAM manufacturers are thus trapped in the game they created.⁴⁷ In early 1997, Samsung tried to cut production in an effort to boost the

however, cannot explain the Japanese pricing structure.

⁴⁷ It is interesting to note that Japan faced similar problems in the transition to the 4M DRAM market when the Koreans were actively dumping the 1M DRAM chips in 1989-90.

price of the 16M. So far they have been very unsuccessful, which is not surprising given the competitive nature of the current DRAM market.

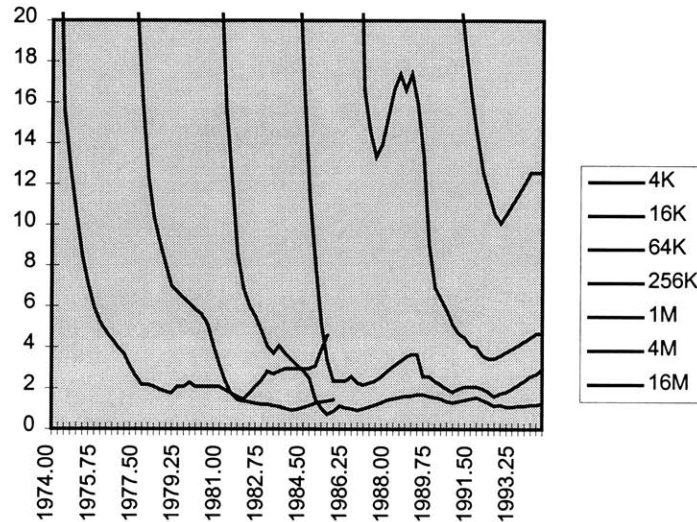


Figure 2.2.3 DRAM Price Cross-over⁴⁸

The fourth area at the corporate level that plays an important role in the DRAM business involves *capacity conversion* and *strategic exit*. Since the DRAM industry has a cyclical nature, firms make huge profits when there is a shortage and lose millions of dollars when the market is soft. The ability to plan and to adjust accordingly is essential. When to convert DRAM production capacity to the new generation is the problem that managers have to solve. Historical DRAM prices display an inverse J-curve pattern largely because the capacity of the old DRAM is reduced at a faster rate than the conversion rate of the industry demand.

⁴⁸ The price cross-overs took place during 1979, 1982, 1985, 1989, 1992 for 4K-16K, 16K-64K, 64K-256K, 256K-1M, 1M-4M respectively.

Firms can choose to stay or exit a DRAM market segment according to their overall strategic position. The Japanese firms in the late 80s tended to leave the mature market to the aggressive Koreans. Many of the U.S. firms chose to exit the DRAM market completely in the mid-80s. This is an extreme case of strategic exit. Intel, for example, moved to the higher-margin, less-competitive microprocessor market. In fact, many argue that Intel's quitting of the DRAM business serves as an excellent model of strategic management.⁴⁹ For the firms that disappeared in the semiconductor scene, it is much harder to argue that they formed any business model at all. ☺

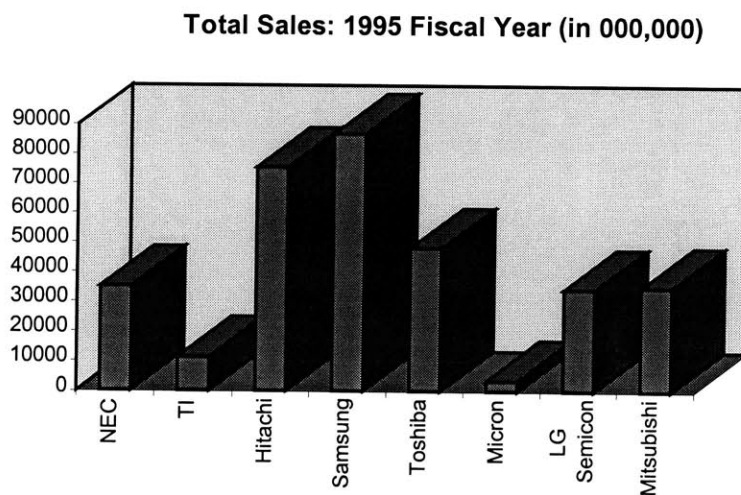


Figure 2.2.2 Disparities in Financial Strength among top DRAM Manufacturers⁵⁰

Last but certainly not least, the history of the DRAM business has shown that large vertically integrated companies such as Samsung and Hitachi have a competitive advantage over the “merchant” chip makers of much smaller scales. (Figure 2.2.2) The reasons behind are manifold. The most important reason is cooperation between the

⁴⁹ [Burgelman, 1996]

⁵⁰ Data from respective company homepages. See Bibliography.

memory and system makers. The cooperation often involves financial, technical and personnel support that significantly improve the DRAM section's competitiveness. It should be noted that scale is as important a factor as vertical integration. Micron Technology is vertically integrated, but their small scale of production limits their ability to invest heavily.

In the United States, such cooperation has been very difficult. In 1989, fourteen years after MITI targeted DRAM, the U.S. semiconductor and electronics companies finally decided to participate in a joint effort to solve America's long-term DRAM problem. The project was proudly named "U.S. Memories". With the system houses including Hewlett Packard, IBM and Digital on board, U.S. Memories would have an assurance of demand. With a stable source of revenue, it would be able to plan in a rational manner for the future. For the system makers, investment in U.S. Memories would provide a reliable source of DRAM supply at a competitive price, immune to changes in foreign industrial policy or fluctuations in foreign demand.

U.S. Memories, however, never made a single chip. The final blow to the project came in early 1990 when the members failed to provide the promised \$500 million in capital.⁵¹ Sanford Kane, U.S. Memories' lone employee and CEO, blamed the failure on the U.S. computer firms' inability to cooperate. The real reason, as many argued, was that the previous shortage in the DRAM market had been met. With a sufficient DRAM supply, the OEMs lost the incentive to cooperate.

⁵¹ [Todd, 1990]

While the U.S. Memories may remain a bitter memory, new efforts are being made in an effort to share risks among DRAM and OEM makers. For example, many major DRAM makers have started joint ventures with OEMs. Samsung and Intel, Texas Instruments and Hewlett Packard are good examples. The rationale behind joint ventures (JVs) is similar to that of establishing U.S. Memories – risk sharing. The reason joint ventures are more attractive is the scale of investment. A joint venture requires a smaller scale of investment for any one participant, and is hence less risky. In fact, JVs represent the new development trend of the DRAM industry as the capital required for R&D and fab construction skyrockets. This is another area that calls for more academic research.

Chapter 3

Model Structure

Chapter Two examined the historical development of the DRAM industry. Numerous dynamics have been identified. This chapter attempts to quantify these dynamics using a system dynamics modeling approach. The goal is to help develop a clearer understanding of these crucial dynamic forces that define the current DRAM market trend.

3.1 Reference Modes

In the world of system dynamics, reference modes display patterns of behavior over time. They are not usually graphs of the exact observed behavior. Rather, reference modes are “cartoons” that show a particular characteristic of behavior that is interesting. (Figure 3.1.1 -Figure 3.1.7) There are two sets of reference modes in the system. The first one involves the set of variables that span more than 25-year horizon. Multi-generations of DRAMs are included in the scenario. The second group has the time span of one DRAM generation, which is significantly shorter. This section will discuss them in detail.

First and foremost, it is important to understand the issue that represents competitiveness – Market Share. The major DRAM producers categorized by country display three distinct patterns. The U.S. started out as the monopoly producer of the DRAM. Its leadership position was evident throughout most of the 70s. With the rise of the Japanese DRAM producers, however, most of the American firms were squeezed out

of the market. Only two – Micron Technology and Texas Instruments -- stayed, and they survived. The U.S. market share stabilized at around 15% by the early 90s. The Japanese entered the market in 1976. Its market power increased substantially over ten years, and its market share peaked in 1987. Since the late 80s, however, the Japanese have been losing market share to a newcomer to the DRAM market – the Koreans. The Korean firms, namely Samsung, Hyundai, and LG Semicon, entered the DRAM market in the mid-80s, and successfully seized a large portion of the market from the Japanese. Samsung is now the biggest supplier in the global DRAM market. As of 1997, the Koreans have approximately the same amount of market share as the Japanese.

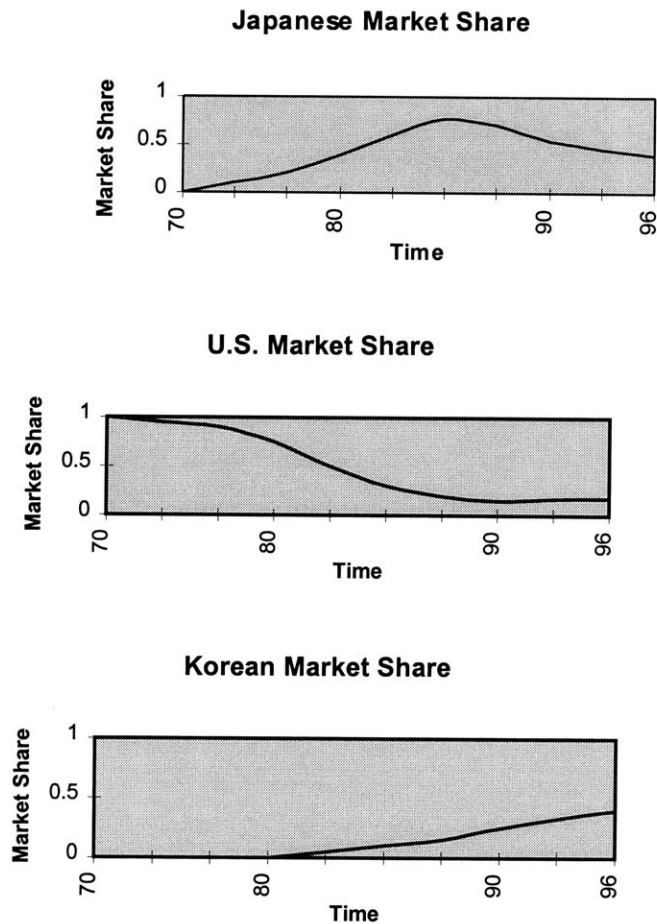


Figure 3.1.1 Market Share Reference Modes

A better understanding of the DRAM market share dynamics has profound policy implications for both government and corporate policy makers as it is closely related to other dynamic forces such as price and availability. It is helpful to examine patterns of these variables as well. The overall demand for DRAM has been growing exponentially.

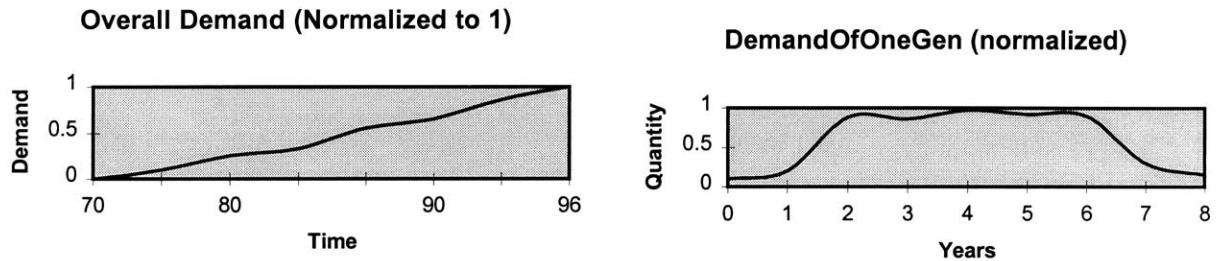


Figure 3.1.2 Reference Modes for Demand

It is worth noting that there are occasional slowing-downs in the growth rate. The demand curve for one generation of DRAM is largely bell-shaped with a steeper curve on the left side. The steep slope reflects the PC industry’s rapid adoption of the new generation DRAM products.

It is important to notice the different strategies that managers adopt to survive in this competitive market. Aggressiveness in pricing, for example, captures the managers’ willingness to lower price. (Figure 3.1.3) The U.S. firms are not at all price-aggressive. The Japanese started out very aggressive, but became conservative after they captured the market. The Koreans have always been very aggressive in pricing as they target on the market share. In fact, the U.S. manufacturers have been seriously hurt by their competitors’ pricing schemes. Dumping has been outlawed as a result of their legal complaint.

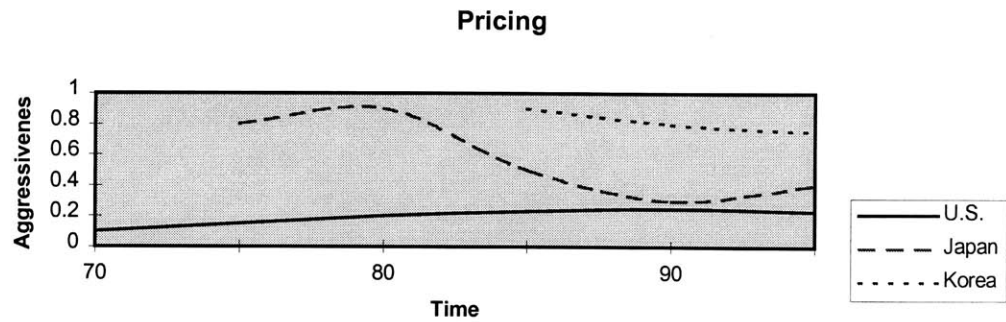


Figure 3.1.3 Reference Mode for Pricing Aggressiveness

Similar patterns can be found in the aggressiveness in capital investment. The Koreans are the most aggressive in capital investment. The Japanese were very aggressive in the late 70s and early 80s. Their investment policy was constrained by the recession in their domestic economy in the early 90s. Recently, they have considerably increased their investment. The U.S. was never very aggressive in capital investment.

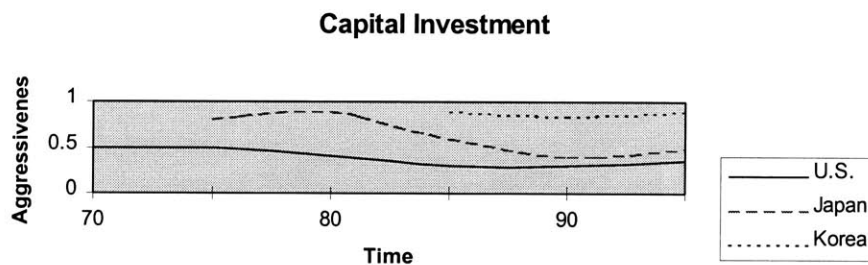


Figure 3.1.4 Reference Mode for Capital Investment Aggressiveness

We can now explore reference modes for the variables with the shorter life span. The cost of production within one DRAM generation is significantly reduced over time. This is mostly evident in the improvement of yield measured as percentage output per wafer. (Figure 3.1.5)

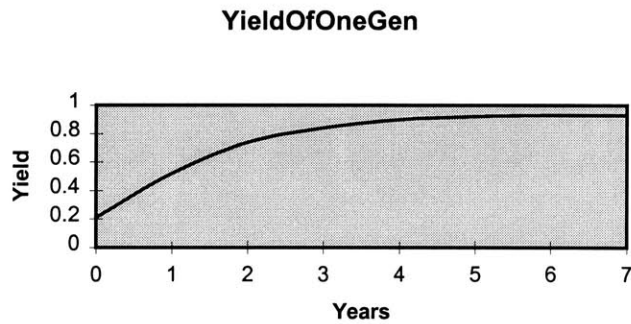


Figure 3.1.5 Reference Mode for Yield Within One Product Generation

The price of one DRAM product displays an inverse J-curve behavior. The price erodes quickly in the early stages as a result of yield improvement. In the meantime, the technology leaders compete with each other for market share, and aggressively cut prices.

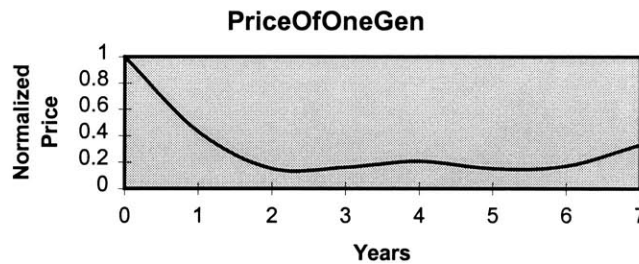


Figure 3.1.6 Reference Mode for Price Within One Product Generation

The price erosion of the new generation DRAM triggers market conversion during which the new generation DRAM becomes industry standard and the old generation of DRAM gradually dies out. When the DRAM market transition is near completion, there is often a shortage in the DRAM supply as a result of managers' conservative investment behavior. Price goes up accordingly. Several fluctuations in prices can be observed in the mainstream DRAM marketplace as firms increase or decrease production. When the profit margin reaches its bottom, top DRAM producers begin to exit the market, and invest in the next generation of DRAM that has a higher

profit margin. The price of DRAM increases slightly as firms pull away capacity at a faster rate than the demand transition. (Figure 3.1.6)

Finally, capacity within one DRAM product generation displays a cyclical, bell-shaped pattern. (Figure 3.1.7) In the early stages, capacity increases exponentially. During its peak stages, capacity oscillates over time. It is worth noting that, in a mature market, capacity fluctuates in a wider range than demand does. Its volume gradually diminishes when the new generation of DRAM takes over the market.

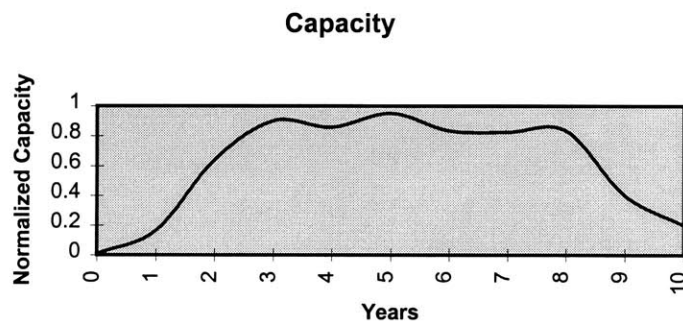


Figure 3.1.7 Reference Mode for Capacity

Why would the factors in the DRAM market behave the way they do? The next step is to clarify the dynamics of the DRAM market using causal loop diagrams.

3.2 Hypotheses

The hypotheses developed in this section are based on the materials in Chapter 2. Discussions with industry managers and extensive readings are the sources of information. Hypotheses are represented in the form of causal loop diagrams. In section 3.2.1, dynamics in the mature market are explored. The discussions include both corporate and government sectors. Section 3.2.2 focus on cross-generation dynamics that take place during market transition. Once

the market completes its transition into the next generation DRAM, the mature market characteristics will prevail.

3.2.1 Mature Market

Causal loops are the feedback loops that represent the complex dynamic structure of a system. The basic DRAM market structure is shown in Figure 3.2.1. This loop set represents the dynamics within the mature market of one generation of the DRAM product – 16M DRAM, for example. Cross-generation dynamics are not included in this loop, but will be touched on later. The loops are drawn in Vensim DSS, a System Dynamics software.

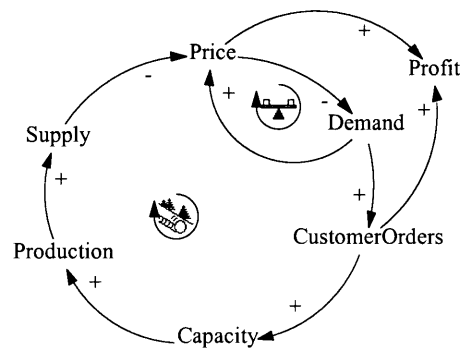


Figure 3.2.1 DRAM Market Loop

First of all, the market contains a strong reinforcing loop. When the price goes down, industry demand goes up which drives up customer orders, capacity, production, and hence market supply. In the meantime, profits are positively related to price and customer orders. One interesting fact of this particular market loop is that profits do not have a direct impact on capacity reinvestment. Historically, companies were lured into the DRAM business by high profitability. Most of them were subsidiaries of

multinational companies with strong financial backing. Their investment pattern often ignores short-term profitability. On the other hand, the DRAM market is both fast growing and volatile. Managers have to constantly reinvest to keep up with the market pace even though occasional downturns in the marketplace can lead to temporary profit disaster. Secondly, price and demand form a traditional balancing loop. If there is a demand drop, price decreases accordingly. Likewise, a price drop stimulates demand. The link from price to demand involves considerable delays on the macro level. The overall market demand is often inelastic to price changes. On the firm level, however, demand which is measured in customer orders is often very price elastic.

3.2.1.1 Corporate Sector

The basic loop is a simplified version of the market. New loops are added to reflect other important forces that shape the current DRAM market. These new loops reflect dynamics created by both corporate players (producers and buyers) and government players. First, corporate dynamics are discussed. The most intriguing of all is the quest for market share through strategic pricing. This loop is particularly strong for Korean firms such as Samsung and Hyundai. Several factors contribute to the lust for market share. One is the high capital investment to establish a DRAM production facility. This capital-intensive nature of the DRAM industry leaves managers very few options for a higher return. Lowering price, also known as dumping if the price is lower than the production cost, is, and has been proven to be, an effective way to penetrate the market. An improved market share, in turn, encourages firms to build more capacity.

The original reinforcing market loop is thus strengthened by this new dynamics. (Figure 3.2.2)

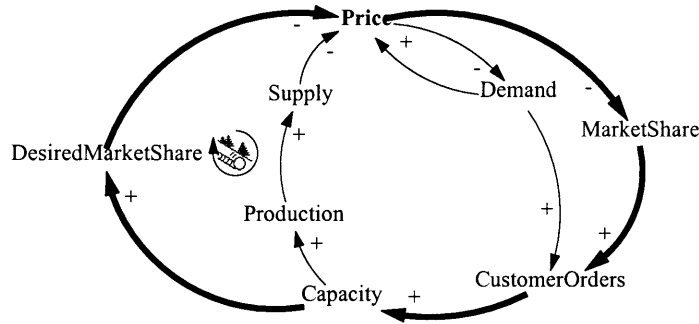


Figure 3.2.2 Pricing Loop

This strategic loop is largely responsible for the quick and large-scale price erosion of DRAM that cannot be explained by the learning-curve phenomenon. Gaining market share, however, does not necessarily mean that the firm's profits will increase. On the contrary, profits will likely decrease given the direct link between unit price and profit. This is evident in the U.S.-Japanese competition of the early 80s for the control of the DRAM market. The Japanese firms lost \$4 billion whereas the U.S. firm lost only half the amount.⁵² Only by driving the competitors out of the market can the firm practicing dumping regain profits. After nine out of eleven U.S. suppliers exited the market, the Japanese happily reaped their monopoly profits in the mid-80s by dramatically raising prices.

The second corporate loop involves the capacity utilization factor. Given the scale of the capital investment in the DRAM industry, managers are unwilling to leave their capacities idle. This behavioral pattern often leads to an inflated market with excess

supply. Figure 3.2.3 shows the new balancing loop created by capacity utilization dynamics. When demand and hence customer orders decrease, normal desired production drops accordingly and brings in the capacity utilization factor. During a market downturn, managers maintain their production at a higher output level than suggested by the current market data. Inflated production results in excess supply, which causes further decreases in prices.

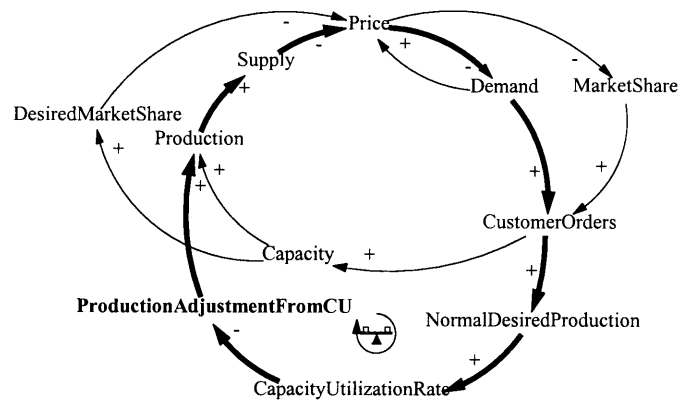


Figure 3.2.3 Capacity Utilization Loop

The third addition to the basic loop set is related to the capacity fluctuations evident in the DRAM market. This loop summarizes the magnification dynamics behind DRAM price hikes and slumps. (Figure 3.2.4)

⁵² [Prestowitz, 1988], p.69

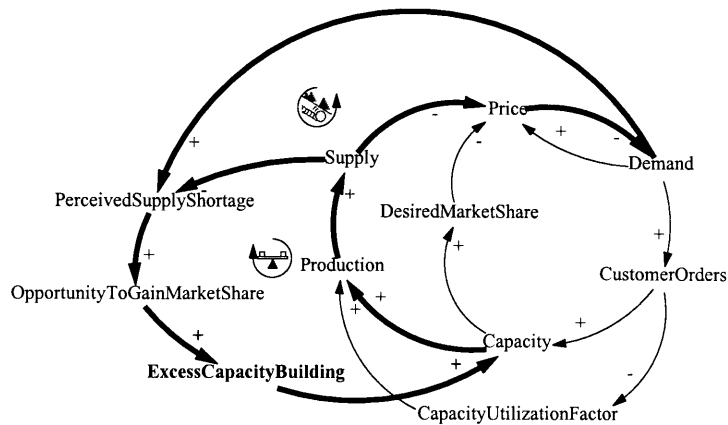


Figure 3.2.4 Capital Investment (Capacity) Loop⁵³

Whenever supply drops or demand increases, managers perceive a shortage between demand and supply. Aware of an opportunity to gain new market share, managers jump to increase production capacity to fill the gap, disproportionate to their current share of the market. Over-capacity naturally follows and price takes a nose dive. If the market is soft, on the other hand, managers will likely to under-invest in capacity for fear of losing more profits if the market sluggishness continues. The industry, therefore, witnesses cycles of over-investment and under-investment.

The fourth loop reflects the role of cost control on market dynamics. (Figure 3.2.5) There are two ways of controlling costs. One is from volume production – the economy of scale. As production volume increases, the yield improves significantly which brings down the unit variable cost. The other source of cost control comes from process technology innovations that reduce unit variable costs. Micron Technology, for example, does not aim at becoming a technology leader. They instead improve their yield and prioritize on profit-making. Since the company does not spend millions of dollars on

capital investment and R&D as their competitors do, they are proud to be "the first in the industry to make a profit".

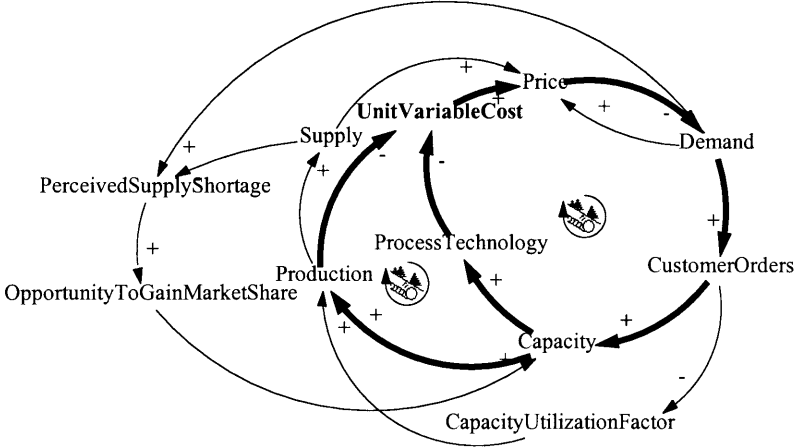


Figure 3.2.5 Learning-Curve Loop

Lower unit production costs make it possible for managers to offer more competitive prices, creating two healthy positive loops for firms. Both control mechanisms demand strong financial and technological sources on the firm level.

3.2.1.2 Government Sector

Government plays an important role in the mature DRAM market. Various forms of government interventions have been discussed in Chapter Two. In this section, we will explain in quantitative terms three kinds of government activities that have a strong impact on the DRAM market and, in particular, on the competitiveness of the domestic DRAM producers. They are cost of capital, production/price control, and market access.

⁵³ Note that the capacity effect discussed is very similar to the one in the classic Beer Game.

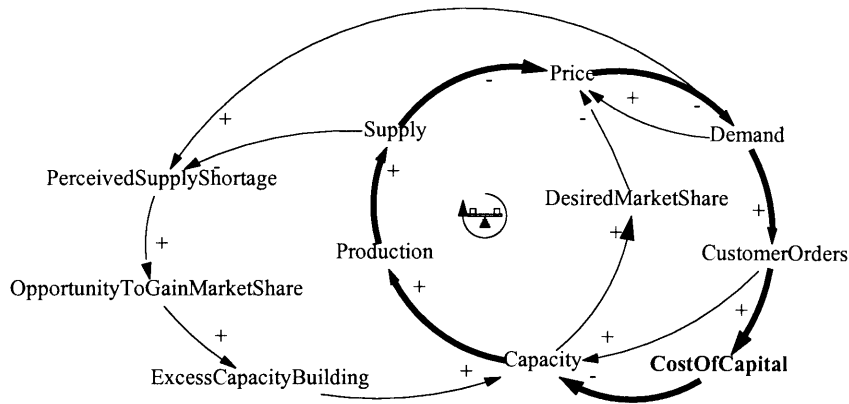


Figure 3.2.6 Financial Incentives

The variable *CostOfCapital* refers to the general financial incentives provided by the government. (Figure 3.2.6) When customer orders decrease, government perceives a need to assist domestic firms to compete more successfully with foreign firms. As a result, they provide firms with low-cost capital, which leads to more capacity building and hence production and sales. In countries like Korea, for example, the government either kept the interest rate very low or provided low-interest loans to DRAM producers. This gives firms a strong incentive to invest in capital equipment than they otherwise would have. The cost of capital played an important role in the catching-up of the Korean firms in the late 80s when the Japanese firms could not afford to invest as aggressively as before due to the economic recession and high interest rate. While financial incentives can achieve important industrial policy goals, it should be noted that the cost to this particular policy is very high. The volatility of the market combined with managerial errors as a result of inexperience often leaves the newborn company in red for a long time.

Government production control is another interesting distortion to the market. There are two kinds of production control. (Figure 3.2.7) One is targeted on controlling over-production for a healthy operation of the market, and the other is cutting normal production strategically to achieve certain market condition. Both have been used extensively. In an oligopoly market, production controls may lead to cartelization of the DRAM producers, as in the case of Japan in late 80s. In a competitive market, production controls are less effective in pushing the price up. In recent years, for instance, both government and firms have tried to use production controls to facilitate market conversion. The result of this policy has been disappointing.

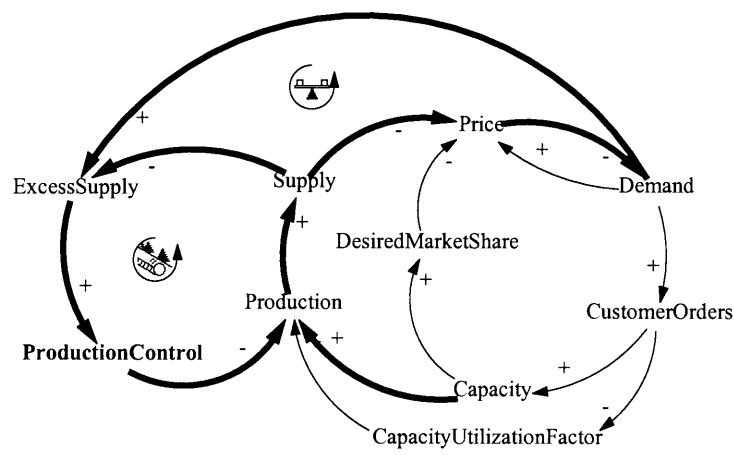


Figure 3.2.7 Production Control

The third kind of government intervention is domestic market access control. This policy is triggered by the same goal as the financial policy discussed earlier – to help domestic firms in face of foreign competition. Once domestic market access is controlled, customer orders for domestic firms increase accordingly. This gives domestic firms an advantage to ramp up capacity and production faster than they otherwise would.

Market access control is a useful policy if there exists a large enough domestic market, as was the case with both Japan and Korea.

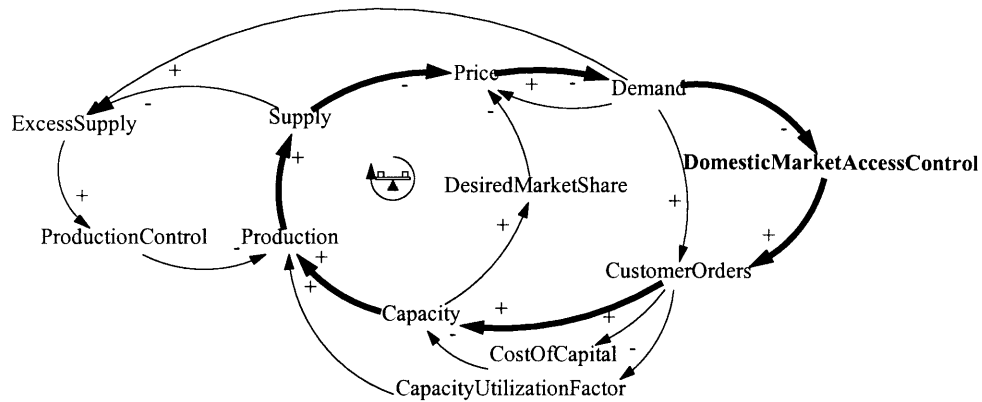


Figure 3.2.8 Market Access Control

3.2.2 Market-In-Transition

After the discussions of the forces that drive a particular DRAM product, it is necessary to examine the cross-generational dynamics. First of all, it is important to understand how market transition starts. When the mainstream DRAM product matures, prices erode quickly as a result of a continuous improvement in the yield and market share competition. The profit margin becomes so small that many big DRAM producers would rather exit the market and concentrate on building capacities for the new generation of DRAM. This behavioral pattern is stronger in the Japanese firms.

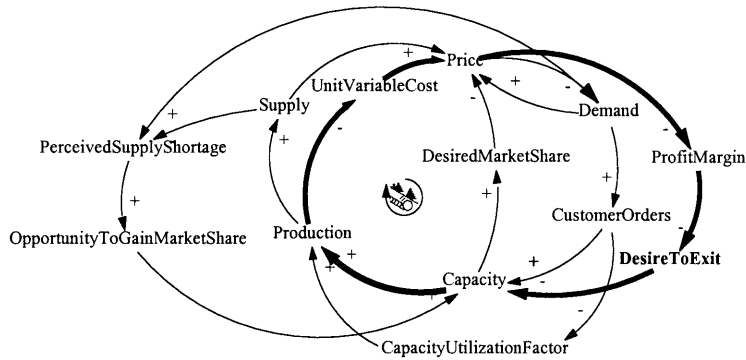


Figure 3.2.9 Strategic Exit Loop

Secondly, there exists a significant amount of the so-called "first mover advantage". The first producer that brings new capacity up in volume captures a significant portion of the market share and monopoly rents. (Figure 3.2.10) The longer the lead time, the higher the profits. One of the reasons that the profit margins are high is that the technology progression of the DRAM market is primarily driven by high-end users such as work-station producers and servers. They are mostly concerned with technology and availability of the new DRAM product. Unlike mainstream PC makers, they are not very price sensitive. Another factor that affects the managers' decision to invest is the erosion of the profit margin in the current DRAM market. Top DRAM manufacturers tend to exit the low-margin market, and shift manufacturing capacity to the new generation of DRAM.

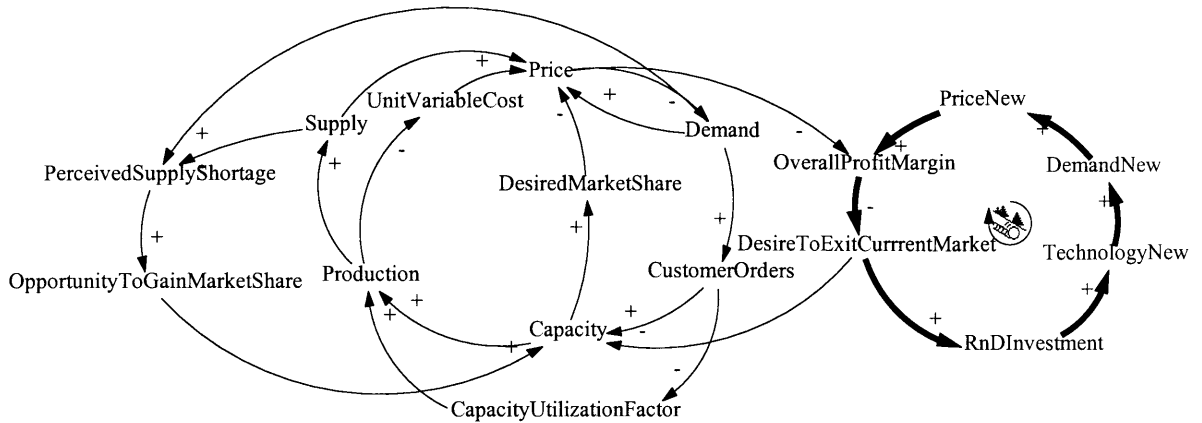


Figure 3.2.10 First Mover Advantage

The competition for market share among technology leaders and continuous improvement in yield bring the price down for the new DRAM. (Figure 3.2.8) There are two reinforcing loops that are at work. One comes from yield improvement as production increases. Another comes from the desire for market share. Once the managers have invested millions of dollars in the new capacity, their primary goal is to capture market share. It is important to understand why managers want market share rather than profits at this stage. Technology leaders in the DRAM business tend to be big suppliers as well. They often maintain long-term supply contracts with their customers who are big OEMs. Market share therefore guarantees profits in the future. These two loops together explain DRAM's rapid price erosion during the first several years of its introduction.

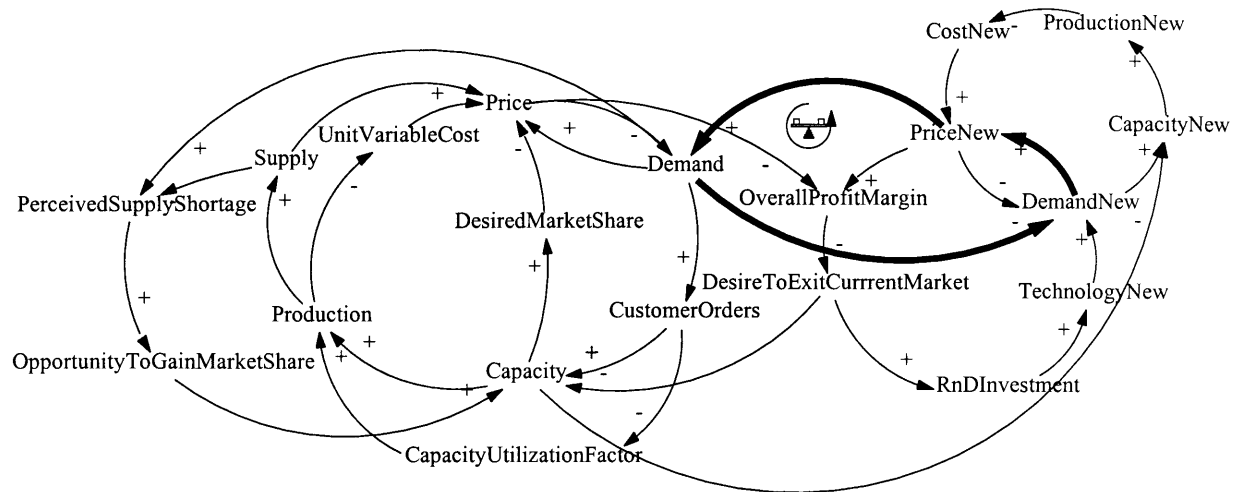


Figure 3.2.11 Market Conversion

As the price for the new generation of DRAM further drops, the prices of the mainstream DRAM product and the new DRAM product approach parity. When the price crossover is reached, the conversion of the DRAM generations by the price-sensitive PC makers, takes place. Demand of the current DRAM product steadily decreases and the demand for the new DRAM product quickly picks up momentum. What is intriguing is that the price of the old DRAM product often increases as the market demand for the old DRAM drops. The explanation can be found in the strategic exit loop (Figure 3.2.11). If managers exit the old market too early, the “relative” supply shortage of a shrinking market will drive the price up. With completion of the generation conversion, the new DRAM market begins to display the same intra-generation dynamics described earlier (Figure 3.2.1 - Figure 3.2.5).

3.3 Model Overview

The system dynamics model represents the interplay of the suppliers, the buyers, the market, and the government. (Figure 3.3.1)

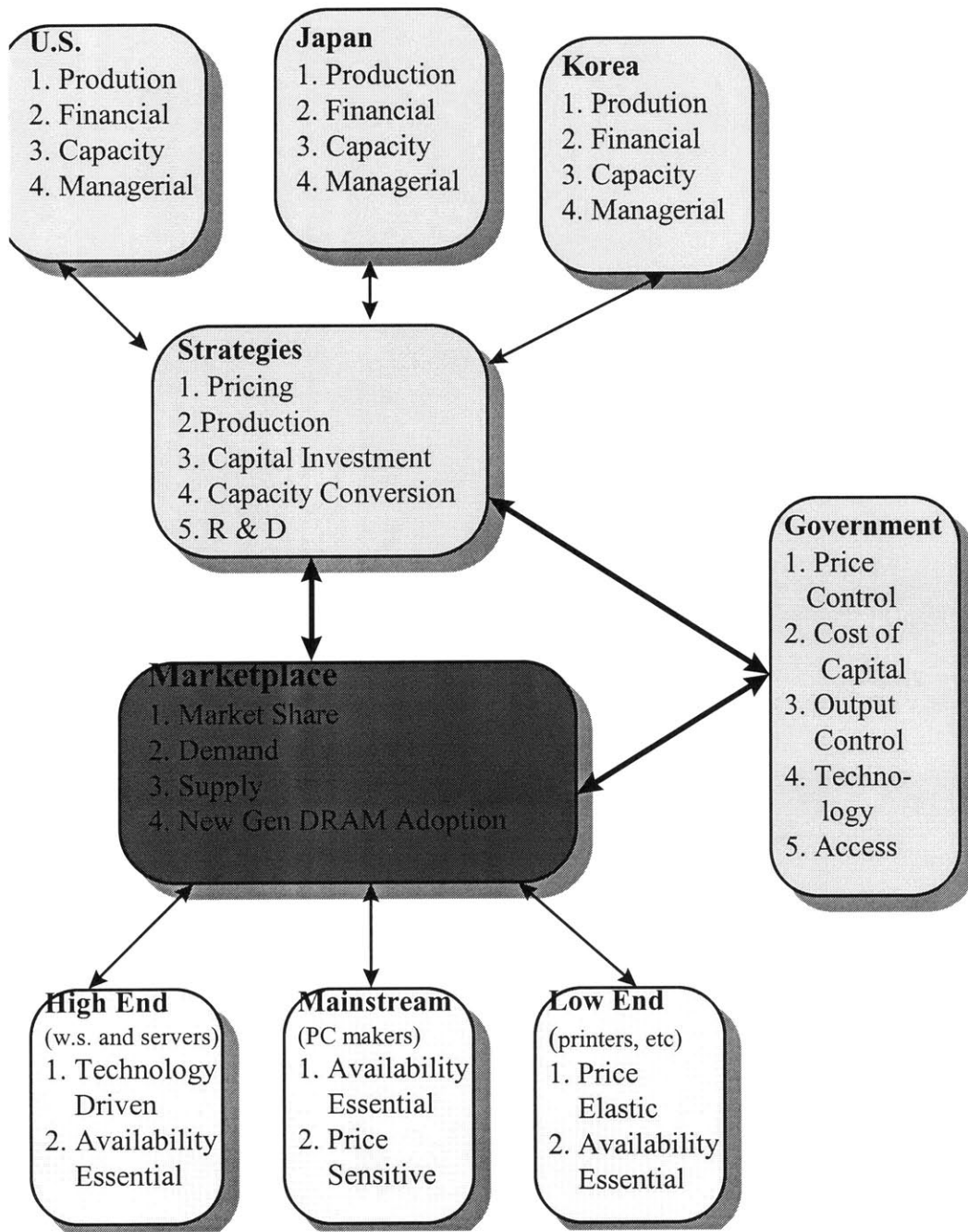


Figure 4.3.1 Model Overview

Chapter 4

Model & Simulation (Part One)

The system dynamics model developed in this thesis includes two subsections -- one which deals with the current DRAM market and the other that deals with the new generation DRAM market. In the current DRAM market section, market conversion from the older generation has been complete. Yield improvement from cumulative production is assumed to be minimum. In this stage, the DRAM market displays traits of a common commodity market. The new generation DRAM market employs the same basic structure. In addition, it has features that characterize the semiconductor industry. For example, there is a steep learning curve from its initial cumulative production. The two sub-models are closely related. The new market gradually takes over the current one as prices approach parity. This Chapter discusses the current market dynamics. The inter-generational dynamics are developed in the next Chapter.

4.1 Model - One Generation

In this model, the sum of the demand for both markets is a constant. If the demand in the new DRAM market increases, the demand in the current market decreases accordingly. It is therefore possible to shut off the new market completely by making its demand zero. We can then examine the dynamics in the one-generation DRAM market.

4.1.1 Pricing

Price is determined by cost and mark-up -- margin. The variables that affect margin are: pressure to change margin, market share pressure, and underlying margin which is a smooth function. There are two kinds of price pressure developed in the model. The first kind comes from a *capacity utilization signal*. When the capacity utilization rate is below unit, managers perceive an over-capacity problem. This might be caused by excessive capacity-building, price-cutting by competitors, or weak demand. They respond by cutting the price mark-up. In the same manner, when the capacity utilization rate is above zero, the price will rise.

The second pressure on price comes from the quest for market share. The Korean firms always want more market share, and they achieve this goal by offering the best price around. In this Chapter, price pressure from market share is assumed to be zero for simplicity.

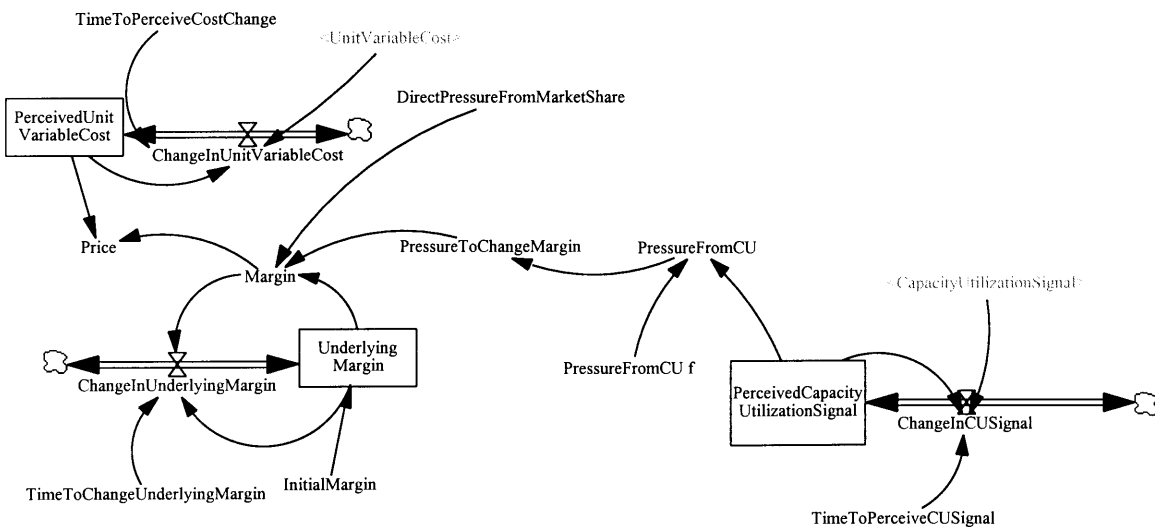


Figure 4.1.1 Pricing

Unit variable cost is delayed by a smooth function to resemble real life. In system dynamics models as well as in real life, dynamic feedback does not take place instantaneously. It takes time for managers to gather information on cost and incorporate that cost data into price. Likewise, capacity utilization rate is delayed to avoid simultaneous equation problems.

4.1.2 Financial

The financial section ignores sunk cost -- capital investment.¹ It reflects the financial information from operations only. Managers use profit signals to make operations and investment decisions. Investment for new capacity, for example, a fab, is often very substantial. Money comes from different sources -- the mother company, loans from the government, and profit from past operations, to name a few. It would be extremely difficult to model the complete financial section. For the purpose of simplicity, therefore, profit is defined as the difference between revenue and cost. (See Figure 4.1.2)

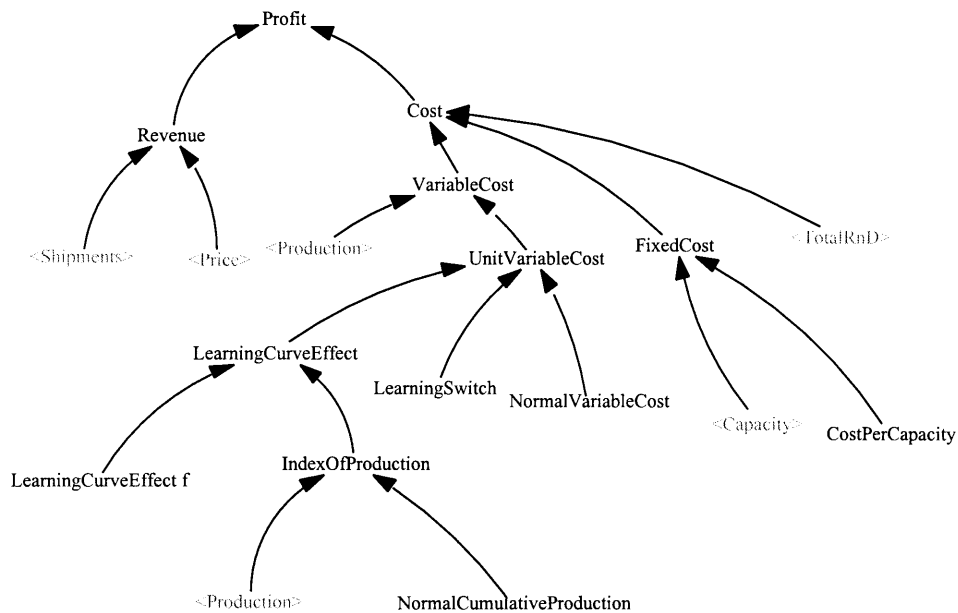


Figure 4.1.2 Financial Section

The learning curve effect in the one-generation model is formulated as a function of production, rather than cumulative production. This is where the DRAM industry resembles a common commodity market with an emphasis on mass production. Volume production is the key to cutting costs once the initial yield improvement stage is over. Firms that are able to ramp up production to greater volume faster will have a significant cost advantage over their competitors.

4.1.3 Capacity

Desired capacity comes from the extrapolated quantity of customer orders. Capacity is estimated from their demand forecast. In this model, capacity building is assumed to be free of financial restraints. Managers can add capacity whenever they deem necessary. At this stage, capital is assumed to be available to all firms at all times.

¹ The impact of capital investment on capacity will be discussed later.

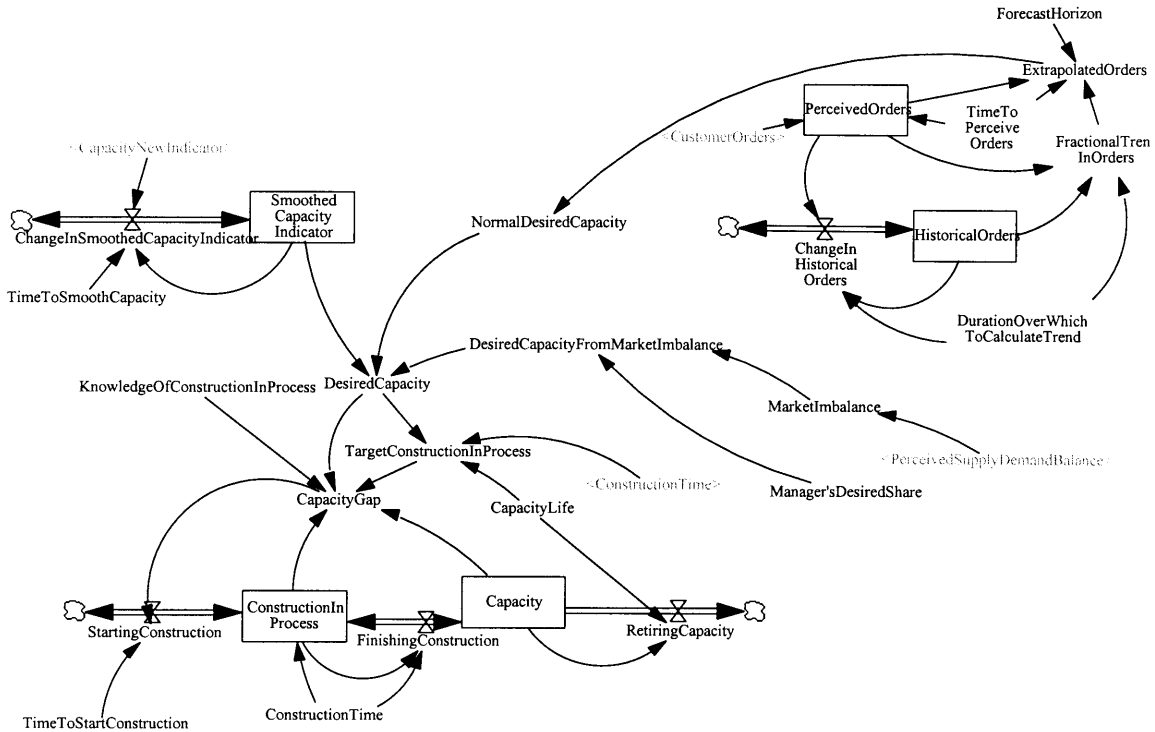


Figure 4.1.3 Capacity

A second source of desired capacity comes from managers' irrationality.

Whenever there is a supply demand imbalance in the market, managers start to over-build if there is a shortage or under-build capacity if there is a surplus. Managers' desired market share is set to unit to reflect the craze.

4.1.4 Production

Desired production based on a company's market share position is formulated as an extrapolation of customer orders. The forecast horizon is one month. In the meantime, managers have to take into consideration the capacity utilization factor. Even if the market is soft, they have to keep up a reasonable capacity utilization rate. The rationale behind this seeming "irrationality" is rather simple. Unless firms believe that their individual behavior such as cutting production will boost price, they are likely to act

in a selfish way to minimize cost. In fact, many DRAM giants tried the production-cutting technique in the past during a shortage. Their effort was undermined by other firms who refused to collaborate. If price does not go up and the firm's production has already been reduced, profit loss will aggregate. During a market downturn, therefore, managers have to guard against the danger of both losing market share and losing profit. Finally, capacity puts an upper limit on the production capability for obvious reasons.

(Figure 4.1.4)

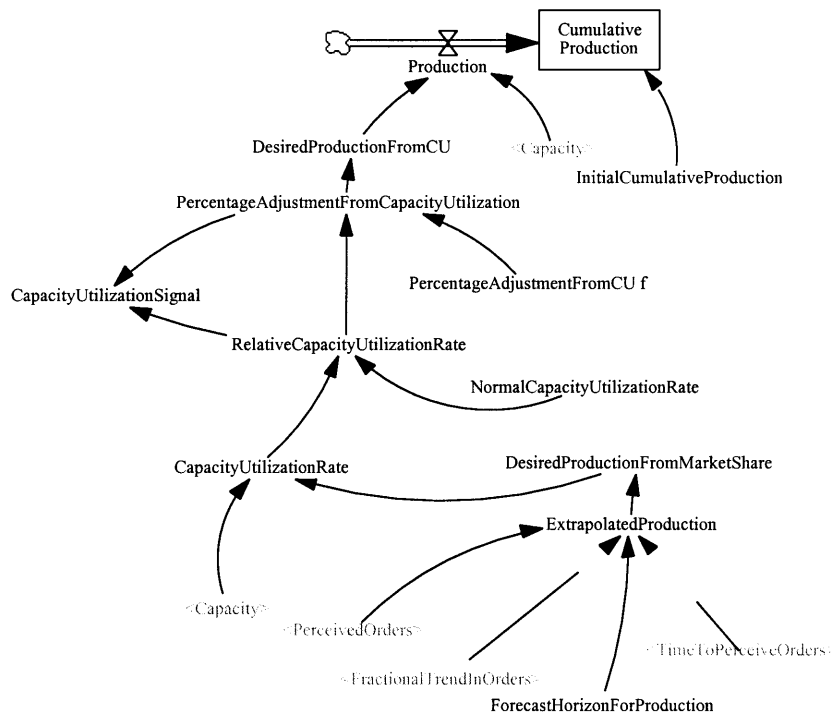


Figure 4.1.4 Production

The formulation of the capacity utilization signal is as follows:

$$\text{Capacity Utilization Signal} = \text{IFTHENELSE} (\text{Relative Capacity Utilization Rate} \geq 1, \text{Relative Capacity Utilization Rate}, \text{Percentage Adjustment From Capacity Utilization} * \text{Relative Capacity Utilization Rate})^2$$

² Relative Capacity Utilization rate is equal to capacity utilization rate if relative capacity CU rate is no less than one.

When the desired capacity utilization rate is high, companies do not make any production adjustments. If the desired capacity utilization rate is low relative to normal capacity utilization rate, however, the product effect takes place. That is why we use the product of percentage adjustment from capacity utilization and relative capacity utilization rate to calculate desired production from CU if relative CU rate is lower than unity.

It is important to note that the product of the Percentage Adjustment From Capacity Utilization and Relative Capacity Utilization Rate is used to reflect the firm-level production adjustment.

4.1.5 Sales

Customer orders come from three demand sources. For the high end demand, whoever comes up with the technology and capacity wins the deal. The current one-generation model assumes the availability of the technology, and the high end demand is therefore left out. (See Figure 4.1.5) Technology will make a difference in the coming of the next generation. The mainstream demand is highly price-sensitive. Those with the lowest prices will have the biggest share. As a result, Firm Price Index and Market Price Index are formulated as inverse prices. Low-end demand is highly price-sensitive as well.

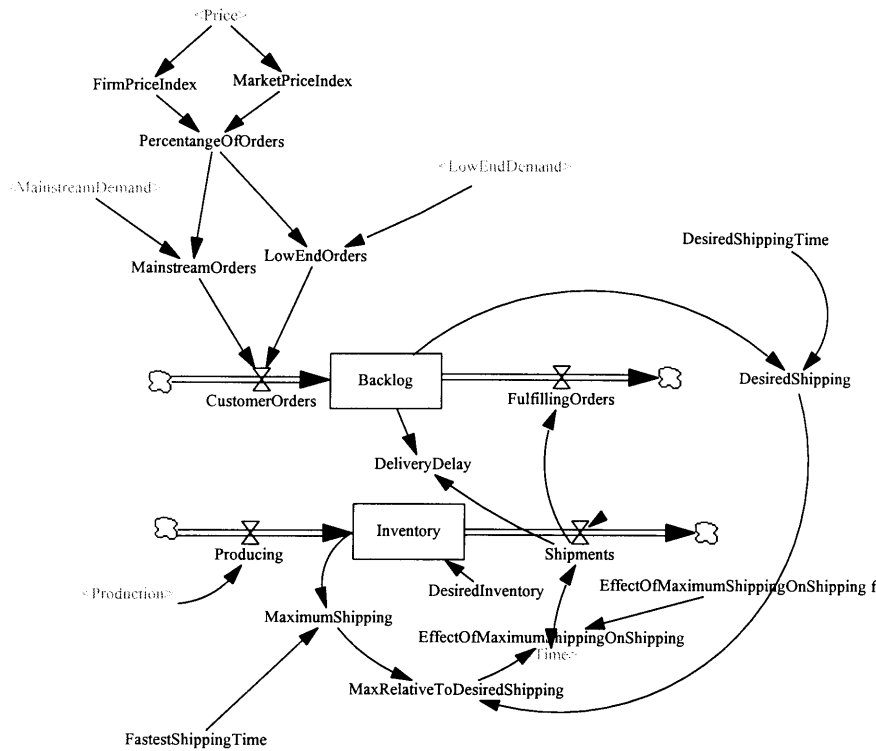


Figure 4.1.5 Sales

Shipping is constrained by inventory. Maximum shipping places an upper limit on how much a firm can ship within a certain time frame.

4.1.6 Demand

As mentioned above, demand has three components. The high-end demand will go away in the context of the current generation when the new generation technology becomes available. The mainstream demand is highly price sensitive. When the price cross-over is reached, e.g. $\text{Price New} = 4 \text{ Price Old}$, the PC world quickly adopts the new generation DRAM. This massive adoption can cause big turbulence in the DRAM market. The ability to cater to the demand increase is essential in becoming competitive in the DRAM business.

The decision to build capacity involves complicated market forecast and risk analysis. If the capacity is built months before or after the market shifts, the firm will likely end up in an disadvantageous position. The low-end demand is also very price-sensitive. Smoothed percentage that becomes new demand is set to zero to shut off the new market.

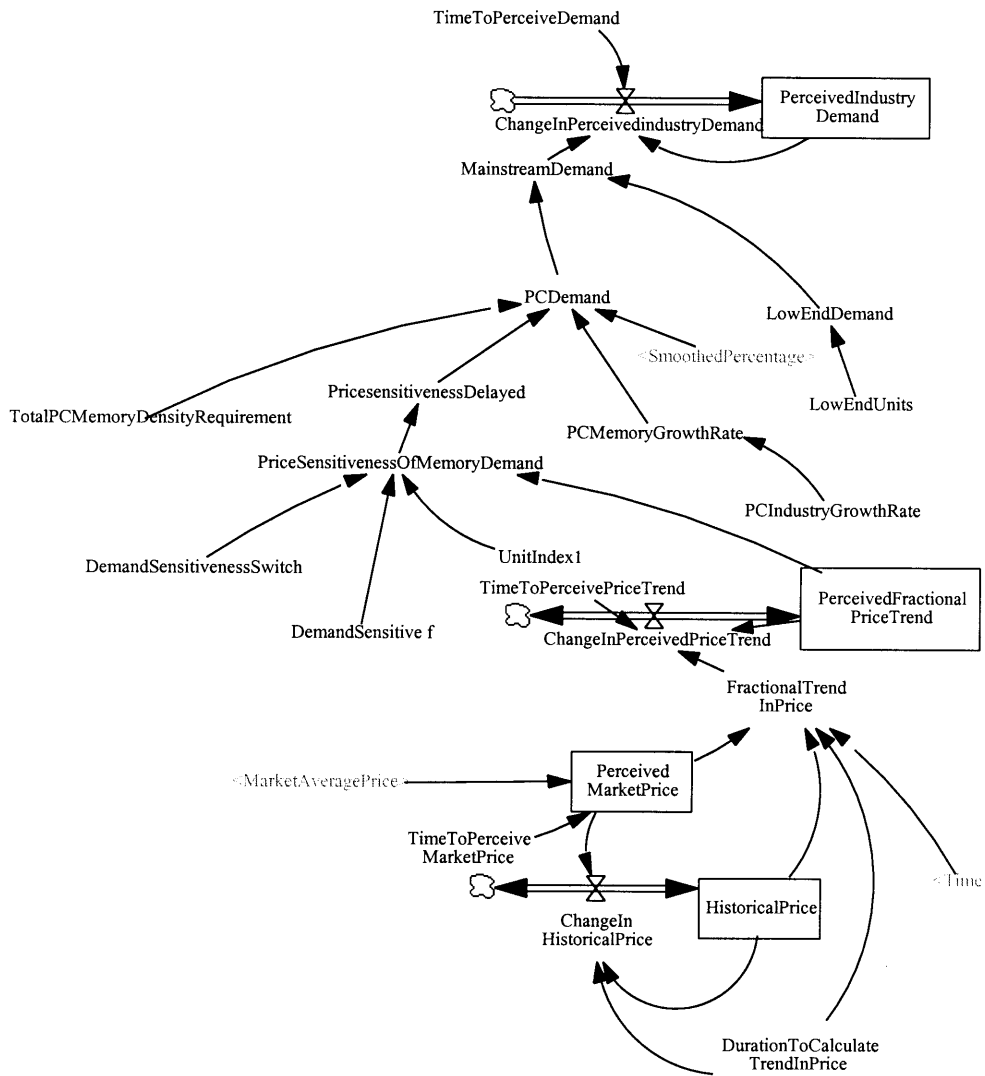


Figure 4.1.6 Demand

Demand is sensitive to price changes. Price trend is measured monthly. Two delays are added to reflect the fact that it takes time for the market to absorb price information and self-adjust.

4.1.7 Marketplace

Supply and demand meet at the marketplace. The balance between them reflects the healthiness of the market. This information is perceived by managers, and feeds back to the whole system after several delays.

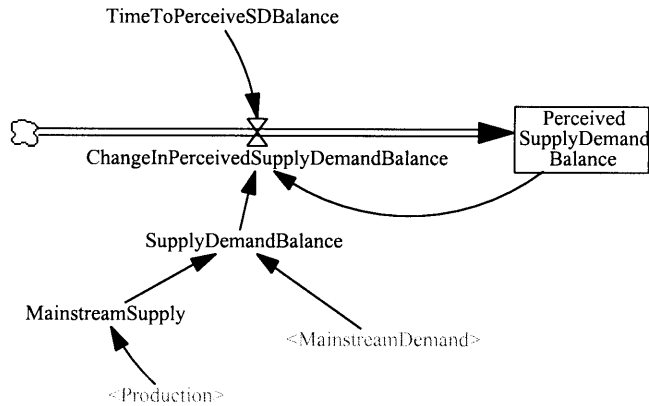


Figure 4.1.7 Supply Demand Balance

There are two market share calculations. One comes from shipments, and the other revenue. It should be noted that market share does not cast any light on profit. A firm can hold a big market share while making little profit. This is what happened to Japanese DRAM makers during their dumping practices. Figure 4.1.8 shows the market share formulation with revenue.

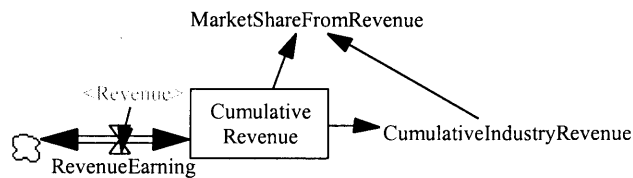


Figure 4.1.8 Market Share

4.2 Simulation Results

Simulation results are grouped into two categories with different emphases. The first one is price dynamics, and the second one is market share dynamics. In the price dynamics section, firms adopt the same corporate strategies, and they each share a third of the market. In the market share section, on the other hand, managers are allowed to design their own strategies. In this Chapter, only the price dynamics within one generation will be discussed.

4.2.1 Price Dynamics - The Basic Market Loop

In the first round, managers are not allowed to build up capacity as they deem necessary. The capacity loop is closed. The learning curve is closed. Capacity utilization rate does not affect production. The model corresponds to the basic market loop developed in Chapter 3 (Figure 3.1.1). The model is tested under the following conditions:

1. “base” -- demand is set constant at 100 million units
2. “demand+” -- demand is step increased by 20%, i.e., 20 million units, at time 60
3. “demand-” -- demand is step decreased by 20% at time 60

The simulation output of price is as follows:

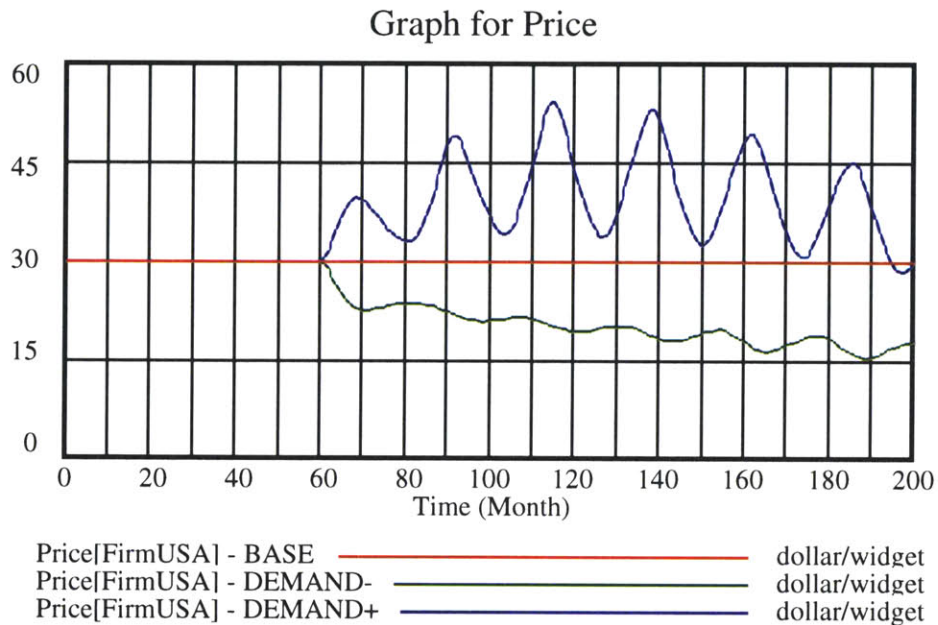


Figure 4.2.1 Simulation Output for Price

When the market demand is set constant, the model is in equilibrium. Price stays at \$30 per unit over time. If there is a step decrease in demand at time 60, customer orders also decrease by the same margin. Since it takes time for capacity to go away, the gap between capacity and production widens. This leads to a sharp decrease in capacity utilization rate, measured by the ratio between desired production from market share and capacity. Price drops according to the signal it receives. The price decrease sends a message to the market, and demand slowly increases. This increase in demand in turn has an immediate direct impact on the firm's capacity utilization rate. Price starts to increase, but to a much lesser extent. This is because it takes time for the market to adjust demand to price fluctuations, and the magnitude of the adjustment is limited. The

time is about 24 months.³ In this scenario, the reinforcing loop in Figure 3.2.1 dominates the balancing loop. The price trend is therefore downward-sloping with oscillations along the way. One might notice that the magnitude of oscillation is growing over time. The reason for this can be found in following discussion of the demand increase run.

Given the symmetry of the model and the experience with the demand decrease run, one would naturally expect similar dynamics in the demand increase test. Rather, the simulation results turn out to be rather surprising. Price exhibits big oscillations, and the overall price trend is not upward-sloping, but rather, bell-shaped with a trailing tail. Before attempting to explain why the system would behave this way, the origin of the fluctuations must be tracked. An important finding comes from the capacity constraint on production (Figure 4.2.2). When demand increases, the firm's desired production immediately goes up. Capacity, however, lags behind this sharp increase since it takes time to build up capacity. The capacity constraint on production places a limit on how much the firm's production can adapt to the market increase. This can be represented by a new balancing loop on the originally strong reinforcing loop. Demand impact on price is further strengthened by capacity constraints (Figure 4.2.3).

³ The cycle time corresponds to the historical data relatively well. A big downturn/upturn cycle often lasts 20-24 months.

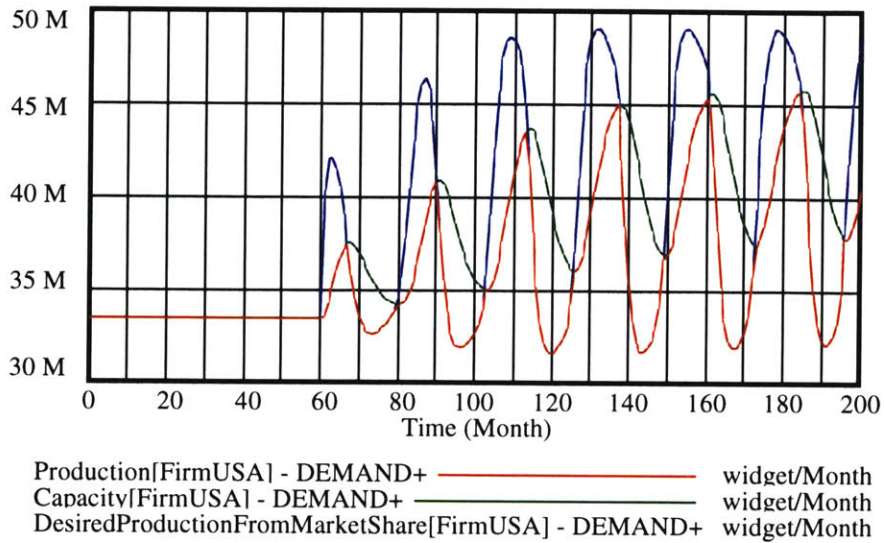


Figure 4.2.2 Capacity Constraint (Demand+)

This also explains why fluctuations are amplified toward the end in the demand decrease case. Demand increase from the price drop puts pressure on the capacity constraint. Before capacity catches up with demand, the system is quite unstable. The system will eventually settle down as capacity and demand reach parity.

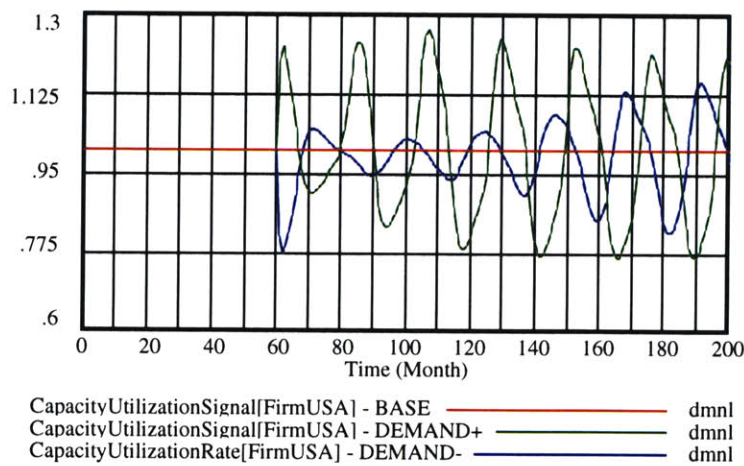


Figure 4.2.3 Capacity Utilization Signal From Demand Change

In the demand decrease situation, desired production drops sharply. This does not cause any problem from the standpoint of the firm's internal operational constraints. Capacity limitation only takes effect when demand rebounds and overshoots. The system is therefore much more stable than in the demand increase case.

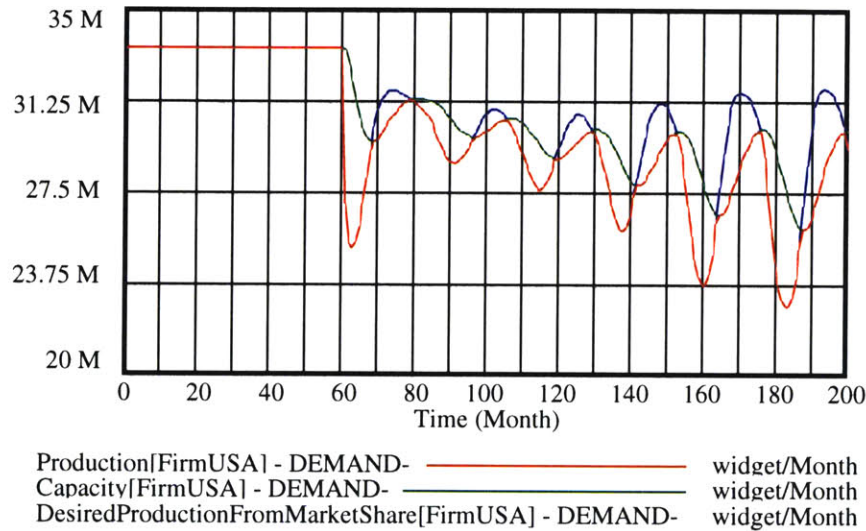


Figure 4.2.4 Capacity Constraint (Demand-)

4.2.2 Hypothesis Testing - Capacity Utilization Rate

In this round, the capacity utilization loop is turned on. When the market is soft, the firm's normal desired production will be small and the capacity utilization rate will be low. Given the expense of capital in the DRAM industry, namely, managers are unwilling to leave their capacity idle. As a result, during a market downturn, production will be inflated. The price will further decrease.

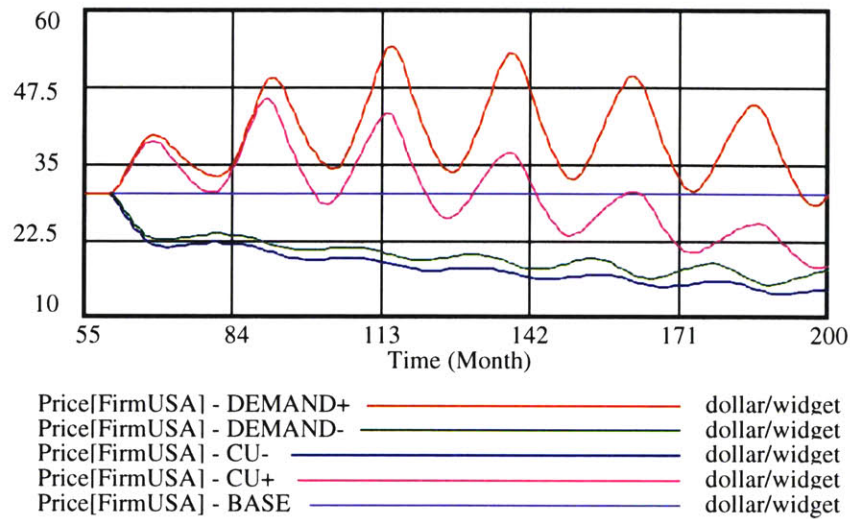


Figure 4.2.5 Simulation Results for Price (CU Added)

Since managers overproduce when there is a bust, the market is less stressed by the step increase of demand as well. This is due to the oscillatory nature of the system. The delivery delay is shorter than the basic demand increase case. The upward pressure on price is therefore less severe.

To summarize, the capacity utilization loop stabilizes the system by limiting the impact of capacity constraint. In both cases, the system stabilizes over the long run. Price reaches equilibrium at a lower value as a result of over-production.

4.2.3 Hypothesis Testing - Capacity

The capacity causal loop diagram (Figure 3.2.3) shows a reinforcing loop that includes demand, capacity building, production, supply and price, and a balancing loop that includes supply, capacity building, production and price. The model is tested against demand changes.

The reinforcing loop from demand strengthens the original reinforcing loop of the market. Aggressive capacity building limits the oscillatory pressure that the capacity constraint is able to exert on the system. The system should be more stable. Following the same logic, when there is a market downturn which is caused by supply drop (an earthquake in Japan that closes down a major fab, for instance), manufacturers will over-build capacity. The model is first tested under the hypothesis that managers only over-build capacity, but do not under-build capacity when there is excess supply.

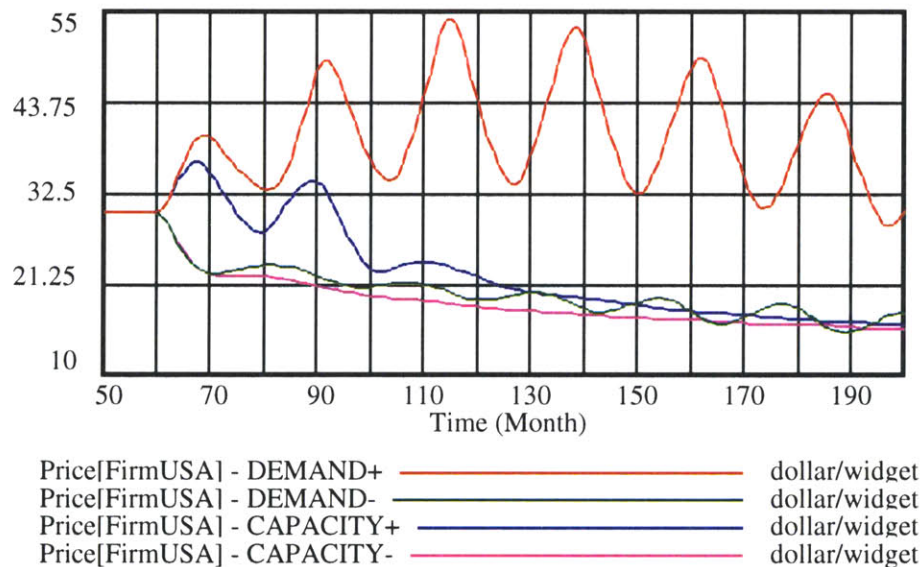
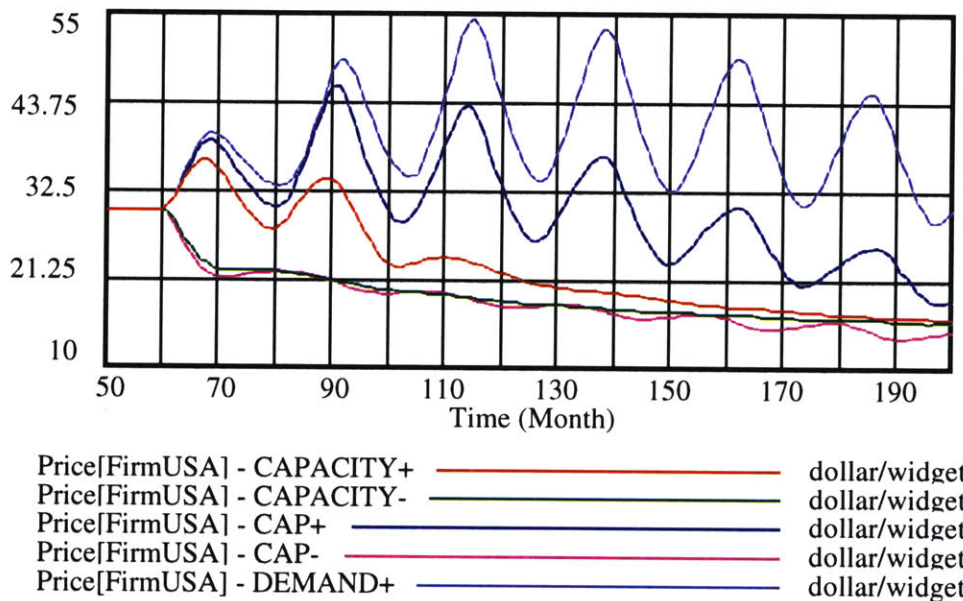


Figure 4.2.6 Simulation Output for Price (Capacity Over-building)

The simulation output conforms to our expectation. In the demand increase case, price has only three obvious “humps”, compared with the oscillatory behavior of earlier scenarios. The system’s stability is much improved. In the demand decrease case, the price curve is almost perfectly smooth. It is interesting to notice that price does not drop as fast as the overproduction (CU-) run. This is because the over-capacity loop is strong when there is a shortage. In a demand decrease situation, the market has excess supply.

For the overproduction run, as long as the production facility is not fully utilized, production will adjust upward. The market does not have to be in shortage.

The analysis is complicated if managers under-build capacity when the market is in excess. The balancing feature of this complication will make the system less stable than the one discussed above during which managers only respond to market shortages.



The capacity loop overall adds stability to the system. How much it can achieve depends on the extent of the irrationality of the managers.

4.2.4 Learning

There are two kinds of learning. One is yield improvement from cumulative production -- learning in its traditional sense. The other comes from volume production. The more production the firm achieves within a time span (a month, for example), the lower the cost. In the one-generation model, only the second kind of learning is included. It is important to note that learning does not play a significant role in the

aggregate industry-level analysis we are conducting now. Cost will only shift price curves, but will not change any basic dynamics. Learning is certainly a major concern for individual firms. It enhances the firm's competitiveness by enabling it to achieve a cost advantage over its competitors. There are more discussions on learning curve in the Chapter on market share and firms' competitiveness.

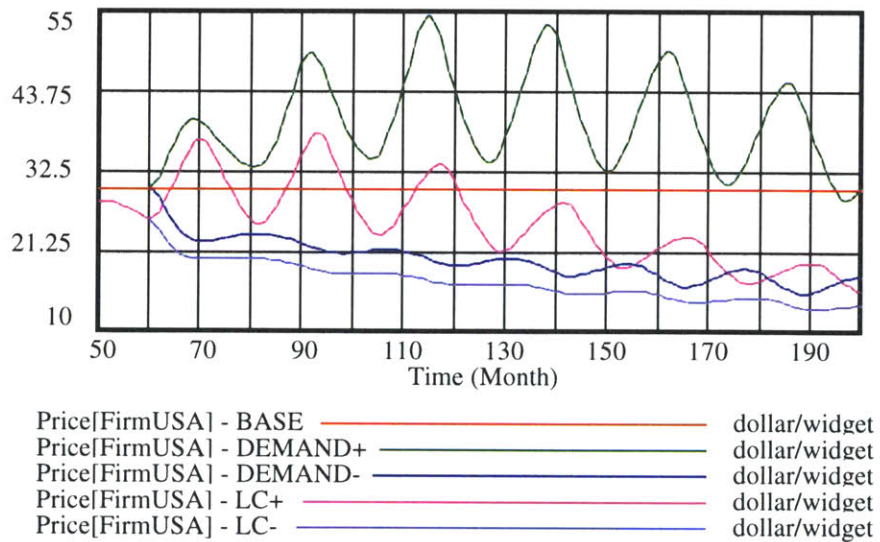


Figure 4.2.7 Simulation Output of Price (learning curve added)

The simulation output with inclusion of learning behavior corresponds to the Learning Loop (Figure 3.2.4). It is another reinforcing loop in the system. The system is therefore more stable.

Chapter Five

Model & Simulation (Part Two)

The one-generation DRAM market resembles a commodity market. The DRAM industry, however, belongs to the high-tech semiconductor industry and so exhibits a complicated technological evolution process. Since the introduction of the first 1K DRAM, there have been more than eight generations of DRAMs. Each generational change represents a step increase by a factor of four in memory density. Price decreases significantly over time. The matured DRAM product is sometimes as cheap as the older generation. Understanding the dynamics that exist across generations is vital to any DRAM market assessment attempt. In this chapter, the inter-generational dynamics are explored.

5.1 Complete Model

The model discussed in this chapter includes both the current DRAM market and the new DRAM market. The two sections have the same general structure. Only the differences will be discussed. In the pricing section, pressure to change margin is turned off before the market completes conversion. This is largely because that market conversion is favorable to the DRAM makers -- margin for the new generation is far better than the mature one. In general, they will make their best effort to facilitate a smooth and rapid conversion.

In the financial section, yield improvement is added to reflect the traditional learning curve phenomenon. In the early stage of development, the price of a new DRAM product drops dramatically as a result of yield improvement. Total market demand for the new generation DRAM includes high-end demand which is technology-oriented. Individual firms attempt to maximize their profit by carefully selecting the timing and scope of their investment.

5.1.1 Technology

R&D is set as a percentage of revenue. The bigger the firm, the more aggressive it is in investing in new technology. The benefits of R&D accumulate over time since technology acquisition is a continual cumulative process. *Cost of technology* is the dollar amount that is generally required to develop the new technology. Firms with the new technology do not necessarily start build up capacity right away. The decision to invest is also determined by a margin factor. Only when margin in the current market deteriorates to a certain low rate will DRAM makers gradually phase out the old capacity and concentrate on building the new.

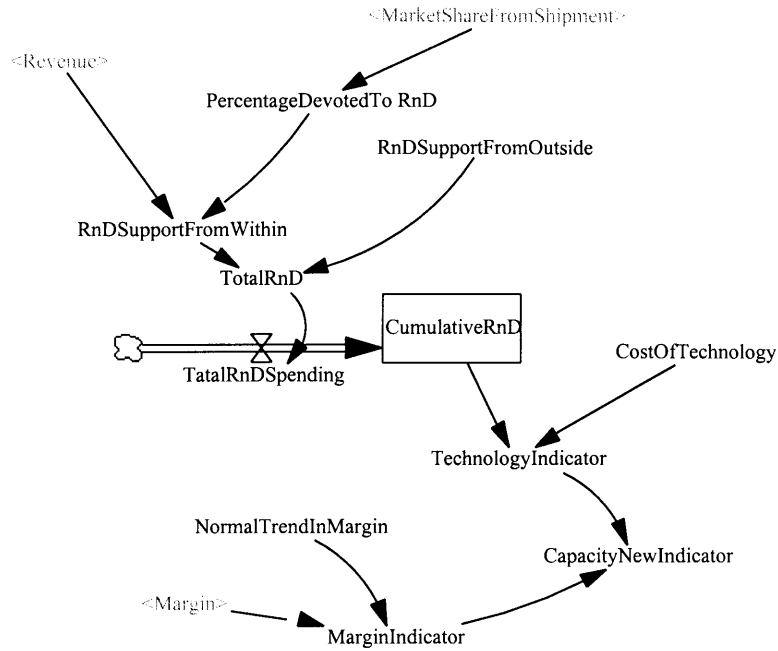


Figure 5.1.1 Technology Sector

5.1.2 New Demand

Demand for the new generation DRAM comes from market conversion. When the new DRAM price approaches the old DRAM price on a per bit basis, OEM manufacturers quickly adopt the new product. In this model, relative price index is the ratio between the prices of the two generations. *PC demand new* is drawn from a table function which specifies how much market demand has been converted into the new product -- “percentage becoming new”. The percentage variable is then delayed to avoid an unrealistic overnight adoption.

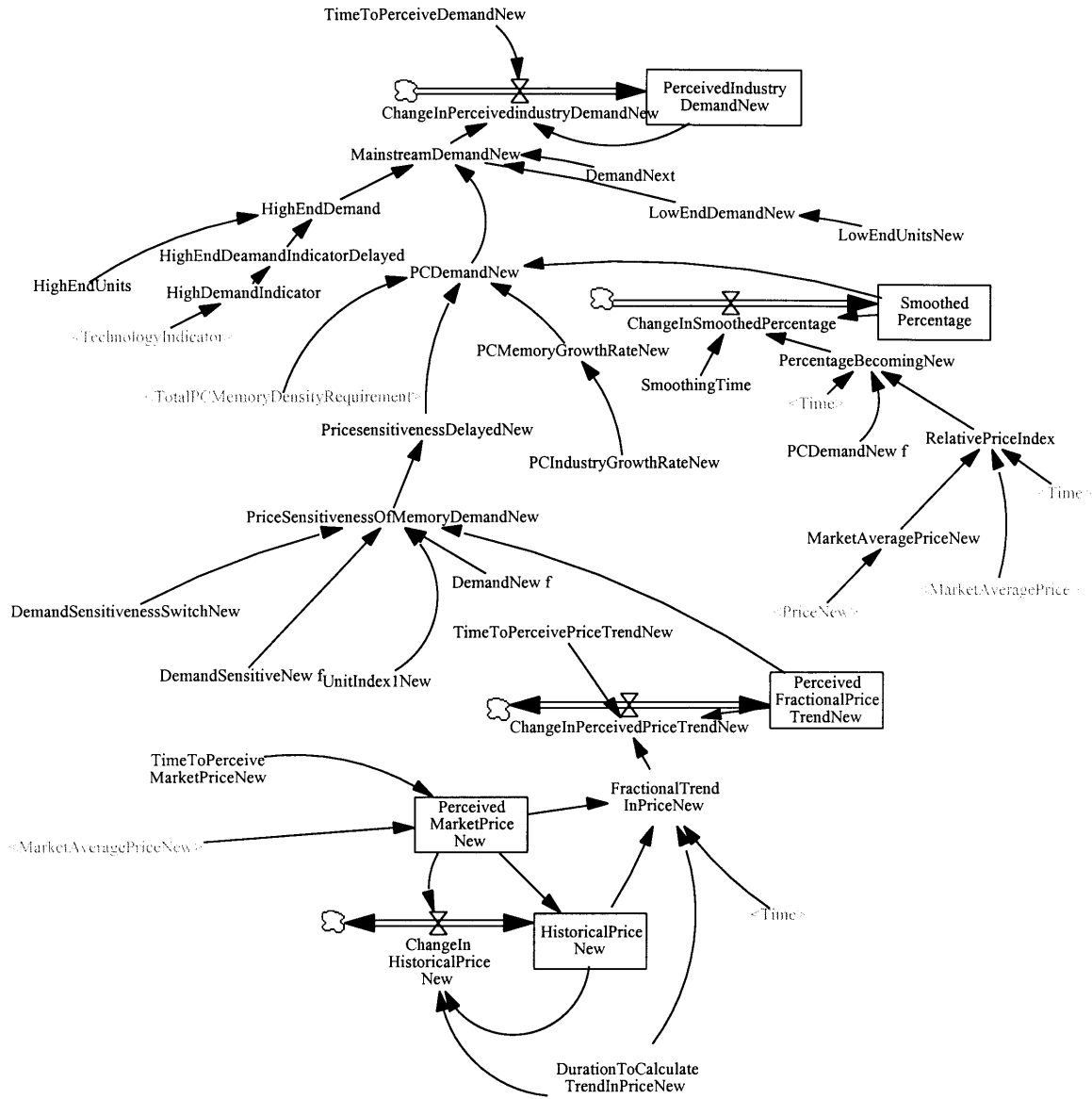


Figure 5.1.2 Demand New

5.2 Simulation Output

The model is tested under the following assumptions:

1. The current DRAM market is in equilibrium
2. Technology will be developed as long as there are ample financial resources

and cumulative R&D

3. Market will convert if price parity is reached

The simulation output for the old price is shown below. Please note that the mature market has been put into equilibrium. If there are no inter-generational dynamics, price shall remain constant over time.

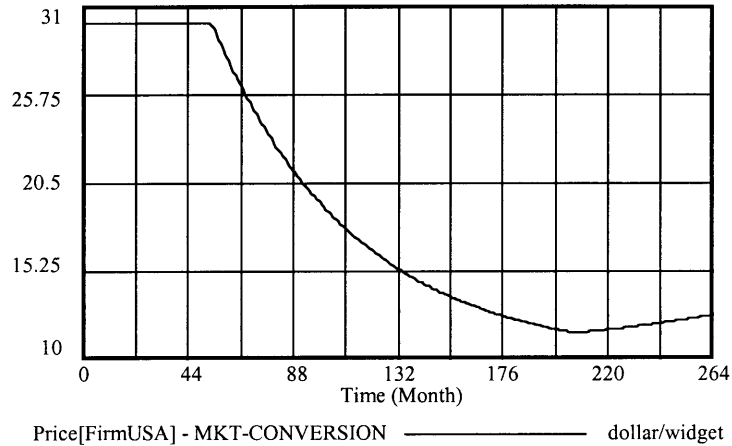


Figure 5.2.1 Simulation Output for Old Price

The price for the current generation DRAM stays in equilibrium until it is disrupted by the advent of the new generation. Price drops significantly as a result of falling demand and low capacity utilization rate. Notice that price eventually goes up. This corresponds to the basic dynamics we observe from historical price data. The reason can be easily traced in the model. In this two-generation version, desired capacity of the current generation is linked to a market factor. If the PC demand has been completely converted to the new market, desired capacity is set to zero. This creates a shortage in the market since low-end demand does not convert as quickly as the PC makers. In fact, much of the low-end demand does not require advanced technology at all. They are left with few options when major DRAM manufacturers cease their old production.

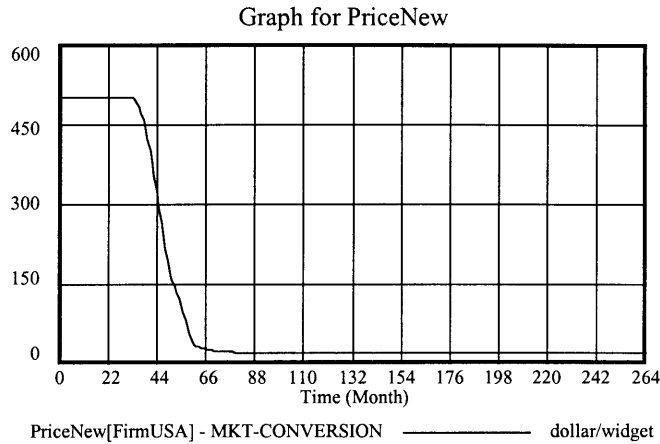


Figure 5.2.2 Simulation Output for New Price

The simulation result for price of the new generation DRAM is shown in Figure 5.2.2. New technology is developed at time 30. The model assumes that technology leaders in the industry start construction of new capacity immediately after the technology is available. Rapid yield improvement drives down unit variable cost. As this high-end-fueled production continues, the price disparity between the two products is reduced dramatically. At about time 52, the PC market starts to adopt the new generation product. Within 12 months, 80% of the PC demand has been converted into the new market.

5.3 Market Share Analysis

The model simulations in the previous chapter and above sections are conducted under the assumption that firms choose the same strategies concerning pricing, capacity and production. The dynamics are in effect consistent with an aggregate, industry-level analysis. For example, price is higher if firms do not over-build when there is a shortage. If firms are allowed to make their own decisions on operations, the

dynamics of the system are much harder to predict. In this section, we will explore the market share dynamics displayed over the history of DRAM. What are the determinants of market share dynamics? How effective are the so-called Japanese strategies that were discussed in Chapter Two?

5.3.1 Price Elasticity

The model is first tested against the price reduction strategy. This is the most frequently adopted strategy for gaining market share in the DRAM business. In the first run, FirmKorea aggressively cuts its price while FirmUSA and FirmJapan maintain their old price strategy. The simulation output of market share points to a problem associated with the model formulation. The *percentage of orders* variable in the Sales section has a price component. It is formulated as the ratio of the inverse price of the individual firm and the sum of the inverse prices in the market. The implicit price elasticity is unity. The percentage increase from customer orders and thus shipments equals the percentage decrease from price in absolute value. The product of the two variables is a constant.

To fix this problem, a variable called the elasticity factor η is added to the model. Assuming the price of the individual manufacturer i is P_i , $i=1,2$ or 3 , the corresponding percentage of orders PoO_i is:

$$PoO_i = \frac{P_i^{-\eta}}{\sum_i P_i^{-\eta}}$$

(for $i=1,2,3$)

The value of η ranges from 0 to $-\infty$:

$-1 \leq \eta \leq 0,$ inelastic customer orders
 $\eta < -1,$ elastic customer orders

In the DRAM market, buyers are often very price-sensitive. Suppliers with the lowest price and guaranteed availability will attract more buyers. This, however, is not an absolute law. In many cases, managers place more emphasis on their relationships with strategic suppliers. They maintain long-term contracts with these suppliers. As a result, their demand is not very price-elastic. During normal market fluctuations, strategic suppliers provide a steady supply with lower-than-market price. Under extreme conditions, they may rise price, but the scale of the increase is often negotiated with their partners. In essence, the volatile nature of the market makes it possible for big producers (Hitachi, Samsung, and NEC) and big buyers (IBM, Intel, and HP) to cooperate in an effort to minimize risk and cost.

5.3.2 Market Share Dynamics in Mature Market

After the model has been adjusted, it is now possible to test different strategies. The single-generation model is used in this section.

Scenario One: Demand is set constant and the elasticity factor is equal to -2 -- Customer orders are quite price-sensitive.

First of all, FirmKorea's initial margin is 1.8 whereas the other two firms' initial margin is 2. This represents the pricing strategy adopted by many Korean and Japanese firms. The simulation output shows that FirmKorea successfully takes market share away from the others. Its profit performance is also very satisfactory. Increased customer orders generate more revenue than expenditures. This simulation result is surprising

because history has shown that firms practicing dumping experience heavy losses before they drive the competitors out of the market. What is wrong with the model? In fact, the elasticity factor is too high at the -2 level given the current model's parameterization. If it is adjusted downward to -1.5, the simulation result conforms to our expectation. FirmKorea gains market share, but loses profit.⁴ The other two firms lose market share, but are quite profitable.

Secondly, FirmKorea is assumed to have a cost advantage over the others. They are then able to offer a lower price to customers while maintaining an industry-level margin. Under these assumptions, FirmKorea clearly has an advantage over its competitors. Both its market share and its profit perform well.

If strategy two is combined with strategy one, i.e., cost advantage plus a pricing strategy, FirmKorea is almost invincible in the market. It controls even more market share, and its profit soars.

Scenario Two: Demand is step-increased by 20% at time 60. In this situation, more strategies can be tested. Managers make individual decisions concerning capacity, production and price.⁵

First of all, everything else being equal, FirmKorea maintains a lower margin than its competitors. This means that FirmKorea always offer the best price in the industry. Its market share exceeds those of its competitors accordingly. What is interesting is profit. Its cumulative profit first lags behind those of FirmUSA and FirmJapan, and then

⁴ Note that FirmKorea is still making positive profit. In extreme cases during which the firm prices below production cost to gain market share, also known as dumping, profit can become negative.

⁵ In the equilibrium scenario, capacity and production adjustment are not effective strategies since the market is in balance.

surpasses them around time 167. This is true even if the competitors are not driven out of the market. In the long run, the increase in shipments compensates for the decrease in price. The life cycle of a given DRAM in the real market is often a lot shorter. The profit cross-over is rarely observed.

Secondly, if FirmKorea is empowered by a cost advantage as well as a pricing strategy, it not only leads in market share, but also surpasses its competitors' cumulative profit at time 7. This is a significant improvement of competitiveness in the market. Samsung is an excellent example of this combination. It leads the industry in both cost control and price reduction.

Thirdly, if FirmKorea overproduces during shortage, it will have a price advantage over others. This is because of the inflated capacity utilization signal the firm receives. FirmKorea will also lead in profit as its market share increase compensates for the price loss.

Lastly, if FirmKorea over-builds capacity during a shortage, its market share will increase as it is able to offer a lower price. It earns more profit than its competitors overall due to increased demand. The profit of the firm is further increased if it not only over-builds during a shortage but also under-builds capacity during a surplus. This strategy performs well if market demand is at the peak of its cycle (Figure 5.3.2).

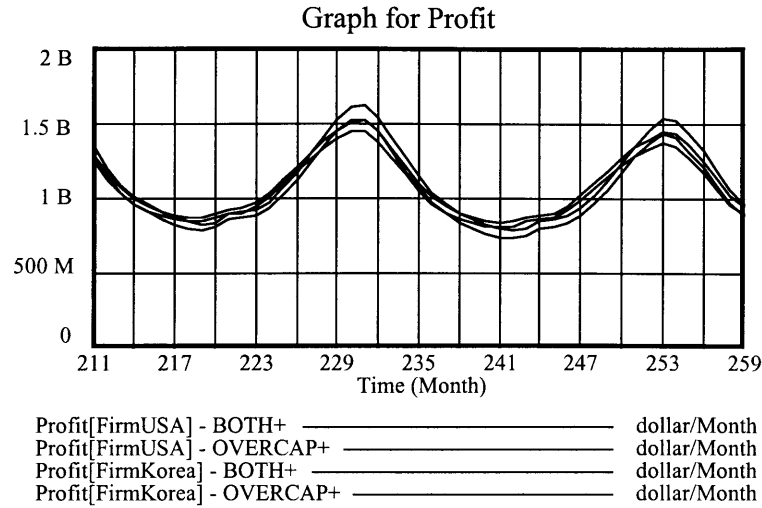


Figure 5.3.2 Simulation Output for Profit (Capacity Strategy)

If this strategy is combined with the price reduction strategy, FirmKorea has an even greater lead in market share. Profit, however, lags behind (See Figure 5.3.3). This result is striking since FirmKorea has a significant market share advantage over its competitors. This simulation result shows that if a firm is very aggressive in pricing, it will gain more market, but at the cost of profit. If it wisely uses price along with other strategies, it will gain both profit and market share. Note that the relative competitiveness of FirmKorea is improved if it both over-builds and under-builds capacity according to different market condition.

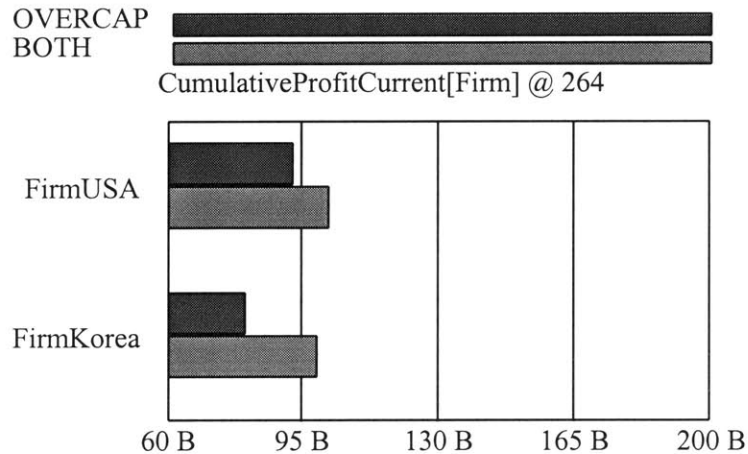


Figure 5.3.3 Profit (in billions of dollars)

Scenario Three: Demand is step-decreased by 20% at time 60. First of all, FirmKorea adopts a price reduction strategy as in Scenario Two. Its initial margin is set at 1.5. The simulation output shows that, contrary to the demand increase case, FirmKorea's profit lags behind that of FirmUSA or FirmJapan despite the gain in market share. A closer examination shows that FirmKorea leads the industry in cumulative revenue. Its cost, however, is also much higher. Profit gain from increased market share is not big enough to offset its loss from price reduction.

Secondly, learning strengthens a firm's competitiveness in a soft market. Low production cost leads to a lower price and hence a higher market share. Profit gain is positive since the original profit margin is maintained. If learning is combined with pricing reduction, FirmKorea will outperform its competitors as long as learning is strong enough to offset margin reduction.

Thirdly, if FirmKorea over-produces during a shortage, its price will be lower than that of its competitors'. However, its variable production cost also increases. If

revenue gain from demand increase cannot offset cost increase from over-production, FirmKorea will not be as profitable as the others.

Finally, if FirmKorea chooses to build capacity in an “irrational” manner during this demand decrease scenario, its profit will not improve. This is due to the fact that demand is arbitrarily decreased by 20% at time 60 from its equilibrium level. While the market struggles to return to equilibrium, demand is relatively weak. In such a situation, a firm’s gain from an increase in market share might not compensate for the increase of its variable production cost.

5.4 Inter-generational competitiveness

Dynamics involving the multi-generation DRAM market are extremely complicated. The model developed in this thesis has only two generations. In the real market, three or four generations can co-exist.

Firms have to make investment decisions concerning R&D and capacity-building for the new generation product. In the DRAM market, development of production technology is relatively easy even though strong financial resources are required. The hardest decision of all concerns capacity-building. Scale, timing, and location are all important strategic factors. While the model developed in this thesis is a much simplified version of the real market, it is possible to discuss the basic dynamics involved in market transition.

First of all, price reduction strategy in the mature market theoretically might delay the development of the new technology since cumulative revenue will be small in the beginning. In the DRAM market, however, there is often a big time lag between the

development of the new technology and the construction of the new capacity. As a result, this constraint is not important. What often happens is that firms practicing aggressive pricing also yearn for technological leadership. They will direct a relatively large proportion of their revenue to R&D compared with their competitors.

Secondly, firms practicing a pricing strategy are more likely to push for market conversion. The dynamics of the model reveal that there is a strong downward pressure for price in the market. This is especially true if firms make irrational decisions concerning capacity and production. In an equilibrium market, if one firm lowers its price, other firms either have to follow the strategy or lose market share. If the majority of the firms engage in price competition, margin decreases rapidly. It is extremely hard to exert upward pressure on price in such a system. Firms are thus trapped by their own strategy. They have little choice but to push the market to adopt the more profitable new generation product.

Thirdly, since availability is a prime concern for high-end users in the DRAM market, firms compete with each other in the capacity-building competition. The earliest entry into the new market segment will bring in the biggest profit margin. For example, 4M DRAM's price was more than \$500 when it first came out in mid-1988. It dropped to \$33 per unit within two years. Firms entering the market in 1989 were faced with a much tougher competitive situation.

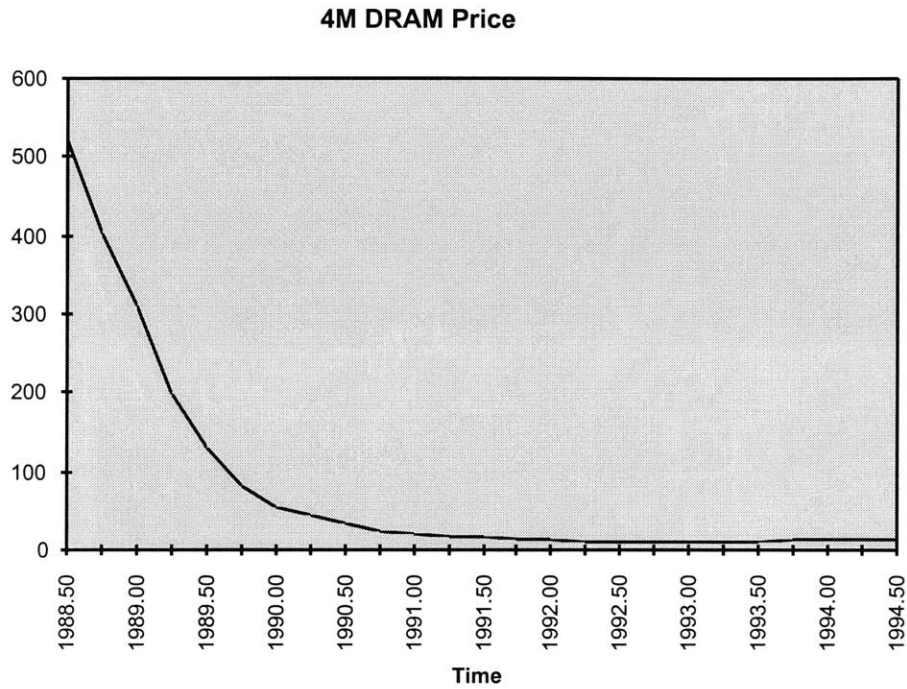


Figure 5.4.1 4M DRAM Price

Fourthly, the transitional period is not only highly profitable, but also highly risky. For example, it is quite likely that the market will delay its conversion due to the price erosion of the current generation. New product will then face a much more hostile market when it first comes out. Firms must therefore have strong resources to shoulder the risks. For smaller firms, it is wise to stay out until the market has completed its transition.

Finally, the basic dynamics of the new DRAM market are similar to those of the current market. All the strategies that have been tested earlier can be used in this market to achieve similar effects after the market transition is over. During the transitional period, the most important strategy is to bring capacity on line at the right time.

Chapter Six

Conclusions

There are two stages of DRAM market development that have been discussed in this thesis. One is the commoditization stage of the DRAM market. This takes place when market conversion is complete and the market displays traits that resemble a traditional commodity market. During this stage, a demand shock, whether an increase or decrease, leads to fluctuations in the marketplace. Firms compete fiercely to gain market share and acquire profits. The second stage is more complicated. It involves the phasing out of the current market and the advent of the new market. Both DRAM producers and high-end buyers are main players during this transitional period. Firms make investment decisions on the basis of their demand forecast and market evaluation. Uncertainty prevails in the marketplace as various dynamics interact with one another, on both intra-generational and inter-generational levels. Investments are therefore highly risky. In the meantime, returns on investment are quite attractive due to less competition.

The current DRAM market is a mixture of these two stages of development. There are more than four generations of DRAMs in the market, and each of them is experiencing one of the sub-stages of the main stages. 4M DRAM, for example, is the mainstream DRAM product, but its market is approaching the transitional stage. 16M DRAM is trying to make its move into the spotlight and replace 4M as the mainstream product. 1M DRAM is experiencing the trailing tail of its demand curve. Only low-end

users are buying them. 64M and 256M DRAMs are only subject to demand from high-end users and they are still quite expensive.

Given the discussions of the DRAM market dynamics, what policy recommendations can be drawn? This chapter will attempt to answer this question based on the findings derived from the model output and the policy review.

6.1 Government

First of all, governments should clearly identify goals for their national industrial policy. The goals often range from trying to build a domestic high-tech industry to maintaining another country's technological lead in the world. Once goals are identified, governments should carefully select policies to achieve these goals.

The model output in this thesis suggests several policy options. For a government whose primary goal is to have a stable DRAM market, it should adopt policies that reduce oscillatory pressures in the market. For example, the government can encourage firms to build capacity when the market condition is not very friendly by offering low credit loans or tax breaks. If firms can maintain a rational investment pattern, the market will become more stable. Rationality here implies investment in a coherent manner. A rational firm should not cut future investment simply because the current market is soft. However, this is easier said than done. Production managers maximize profits over a short time period. They are unlikely to sacrifice their job performance to the stability of the market. Governments therefore have to provide incentives for the firms to adopt such policies.

Another alternative that has the potential to stabilize the market is production control. This policy is less attractive to both government and corporate leaders. One reason is that its stabilizing effect is not as strong as the capacity policy. It takes the market much longer to return to equilibrium. In the meantime, over-production leads to price-reductions that are detrimental to the interests of the producers. As shown in the previous model simulation output, the system often settles down to a much lower price.

For a government whose goal is to increase international competitiveness of its domestic firms, it can choose a learning policy. Governments can assist learning in many ways. Government-sponsored product development programs will provide domestic firms the necessary production technologies that are otherwise expensive to acquire. This policy is familiar to both Japanese and Korean governments. In the U.S., individuals firms are responsible for their technological development. For them, the game is much harder to play.

The national government is often the sole savior of its domestic industry. Even though it can be argued whether governments shall intervene in the market or not, various market deficiencies make such interventions crucial. For those governments that acknowledge the significance of the DRAM industry, therefore, they should make every effort to make their domestic firms' entry into the global DRAM market smoother and faster. In the meantime, national governments shall fully realize the potential financial risk involved in the DRAM business. The costs may be politically dangerous sometimes. In order to involve into a modern industrial nation, however, such an effort is necessary.

6.2 Corporate

Corporate leaders are profit-maximizers. They are also concerned with the healthiness of the market. A volatile market makes decision-making much more complicated, and investments become much riskier.

For the purpose of profit-maximization, the model suggests several policy options. Price reduction leads to a greater market share. However, short-term profit is reduced. This is especially true if customer orders are not very responsive to price changes, i.e., if there are strong buyer-supplier relationships. Unless the price sensitivity is very high, firms practicing price strategy have to prepare for a profit decrease. In the model, the firms that refused to lower price enjoyed a good profit. This is somewhat unrealistic. In the real market, firms have to adjust their price relative to their competitors' prices. The situation is often a lose-lose proposition. The followers in the price war are trapped in a very disadvantageous situation where they lose both profit and market, even though they lose less profits than the price war leaders. Imagine a firm that is losing both money and market share. How long can it survive? Not very long if it is in the Anglo-Saxon type of the market where short-term profit is very important.

Cost reduction is another important requirement to remain competitive in the DRAM industry. DRAM is a relatively standardized product. Firms that can produce DRAMs at a cheaper cost can offer a lower price while maintaining the same profit margin as their competitors.

In the DRAM market, firms tend to over-produce in a weak market. Model output suggests that such a policy does not improve firms' profit situation much. Such a policy

will drive the price even further. Unless demand can be stimulated by price reduction, firms are likely to lose more money. In this situation, firms can consider alternatives such as developing niche products or converting capacity into producing the new generation DRAM.

Finally, firms should plan capacity investment in a rational manner. The model outputs show that irrational capacity building will lead to greater cumulative profit in the long run. Within a shorter time frame, however, such irrationality will expose firms to greater risks if the market is very unstable. The model only examines one shock. If another demand shock happens when the market is still trying to return to equilibrium, the cyclical nature of the market will worsen.

6.3 The DRAM Experience

The DRAM industry is unique in many ways. It is a semi-commodity, semi-high tech industry. There are two kinds of forces in its development. The vertical one is technological evolution. This trajectory is fueled by the development of the overall semiconductor and computer industry. The demand for more density and the improvement of the manufacturing equipment combine to push the DRAM industry to evolve along with them. The horizontal force is commoditization. Large scale production drives down cost. Fierce competition prevents any significant price hikes such as those experienced in late 80s. Demand and supply imbalances lead to fluctuations in the market as firms struggle to gain more market share.

It is important to note that technology does not constitute a strong barrier in the DRAM market if the firm is already in the market. To put it another way, firms that have

the production capability to produce 4M DRAMs also have the technology to produce the 16M DRAM. Technology across generations does not require significant breakthroughs. This is where chips like microprocessors differ from DRAM. In the DRAM industry, the decision to build capacity for the new generation chip is largely market-oriented. Is the market ready for a conversion? If managers conclude that the time is right, they will start producing the new generation of chips. It should be noted that the questions when to construct the new fab and how much to produce remain core strategic issues. Impromptu managerial decisions will jeopardize the firm's competitiveness.

In the world of design-rich chips, technology occupies a stronger role. A firm that produces 486s alongside with Intel in the microprocessor market may not have the technology to produce Pentium-equivalent chips even years after Intel comes up with the technology. Technology across generations often constitutes a barrier. This is especially true for semiconductor firms from emerging markets whose technology is not quite as advanced. This is why DRAM is an ideal industrial policy target for developing countries, while the micro-processor industry remains a far-reaching goal.

APPENDIX

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Model Documentation

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Model Documentation

EffectFromProcessInnovation = A FUNCTION OF()

~
~ |

ProfitEarning[Firm]= Profit[Firm]

~ dollar/Month
~ |

TotalCumulativeProfit [Firm]=

CumulativeProfitCurrent[Firm]+CumulativeProfitNew[Firm]

~ dollar
~ |

CumulativeProfitCurrent[Firm] = INTEG(ProfitEarning[Firm],0)

~ dollar
~ |

PressureFromCU1 f ((0,-0.1)-(2,0.1),(0.00515464,0.0977528)
,(0.572165,0.0722846),(0.819588,0.0370786),(1,0),(1.08247,-0.0468165)
,(1.25258,-0.0857678),(1.45876,-0.0910112),(1.98454,-0.0970038)
)

~
~ |

ElasticityFactor = -1.5

~ dmn1
~ |

ProfitEarningNew [Firm]= ProfitNew[Firm]

~ dollar/Month
~ |

CumulativeProfitNew[Firm] = INTEG(ProfitEarningNew[Firm],0)

~ dollar
~ |

IndustryRevenue = SUM(Revenue[Firm!])
~ dollar/Month
~ |

MSFromRevenue [Firm]= IF THEN ELSE(IndustryRevenue=0,0,
Revenue[Firm]/IndustryRevenue)
~ dmn1
~ |

ExtrapolatedProductionNew[Firm] =CustomerOrdersNew[Firm]*(1+
FractionalTrendInOrdersNew[Firm]*(
TimeToPerceiveOrders[Firm]+ForecastHorizonForProductionNew[Firm]))
~ widget/Month
~ |

PCOrdersNew [Firm]= PCDemandNew*PercentageOfOrdersNew[Firm]
~ widget/Month
~ |

PerceivedOrdersNew [Firm]= SMOOTH(CustomerOrdersNew[Firm]-
HighEndOrdersNew[Firm]
, TimeToPerceiveOrdersNew[Firm])
~ widget/Month
~ |

PressureFromCUNew[Firm] = IF THEN ELSE(SmoothedPressureSwitch[Firm]>=1,
PressureFromCUNew f[Firm](PerceivedCapacityUtilizationRateNew[Firm]),0)
~ dmn1
~ When capacity utilization rate is below unit, managers cut price as a response to
overcapacity.
|

SmoothedPressureSwitch [Firm]= DELAY1(PressueSwitch[Firm],6)
~ dmn1
~ |

PressureToChangeMarginNew[Firm] = 1
-PressureFromCUNew[Firm]
~ dmn1
~ |

CUSignalNew[Firm] = IF THEN ELSE(RelativeCapacityUtilizationRateNew[Firm]>=1,

RelativeCapacityUtilizationRateNew[Firm],
 PercentageAdjustmentFromCapacityUtilizationNew[Firm]*RelativeCapacityUtilizationRateNew[Firm])
 ~ dmn1
 ~ |

ChangeInCURateNew [Firm]= (CUSignalNew[Firm]-
 PerceivedCapacityUtilizationRateNew[Firm])/
 TimeToPerceiveCURateNew[Firm]
 ~ dmn1/Month
 ~ |

DesiredProductionFromCUNew[Firm] =
 PercentageAdjustmentFromCapacityUtilizationNew[Firm]*
 CapacityNew[Firm]+DesiredProductionFromMarketShareNew[Firm]
 ~ widget/Month
 ~ |

HighEndOrdersNew[Firm] = IF THEN ELSE(TechnologyIndicator[Firm]>=1,
 HighEndDemand*PercentageOfOrdersNew[Firm],0)
 ~ widget/Month
 ~ |

CapacityUtilizationSignal[FirmKorea] = IF THEN
 ELSE(RelativeCapacityUtilizationRate[FirmKorea]>=1,
 RelativeCapacityUtilizationRate
 [FirmKorea],PercentageAdjustmentFromCapacityUtilization[FirmKorea]*
 RelativeCapacityUtilizationRate[FirmKorea])*0+
 RelativeCapacityUtilizationRate[FirmKorea] ~|
 CapacityUtilizationSignal[FirmJapan] =
 RelativeCapacityUtilizationRate[FirmJapan]+PercentageAdjustmentFromCapacityUtilization
 [FirmJapan]*0 ~|
 CapacityUtilizationSignal[FirmUSA] =
 RelativeCapacityUtilizationRate[FirmUSA]+PercentageAdjustmentFromCapacityUtilization
 [FirmUSA]*0
 ~ dmn1
 ~ |

ChangeInSmoothedCapacityIndicator[Firm] = (CapacityNewIndicator[Firm]-
 SmoothedCapacityIndicator[Firm])/TimeToSmoothCapacity[Firm]
 ~ dmn1/Month
 ~ |

SmoothedCapacityIndicator [Firm]= INTEG(ChangeInSmoothedCapacityIndicator[Firm],0)

~ dmn1
~ |

TimeToSmoothCapacity [Firm]= 18

~ Month
~ |

ChangeInPerceivedPriceTrendNew = (FractionalTrendInPriceNew-PerceivedFractionalPriceTrendNew)/

TimeToPerceivePriceTrendNew

~ fraction/Month/Month
~ |

HighEndDeamandIndicatorDelayed = DELAY3(HighDemandIndicator,6)

~ dmn1
~ |

PriceSensitivenessOfMemoryDemandNew = IF THEN

ELSE(DemandSensitivenessSwitchNew=1,

DemandSensitiveNew f(PerceivedFractionalPriceTrendNew*UnitIndex1New),

DemandNew f(PerceivedFractionalPriceTrendNew))

~ dmn1
~ |

DemandNew f ((-0.09,0.8)-0.06,1.2),

(-0.0896134,1.10112),(-0.0497423,1.09963),(-0.0244845,1.07416)

,(-0.0142268,1.0427),(-0.001,1),(0,1),(0.001,1),(0.0105155,0.969288)

,(0.0198454,0.925843),(0.0497423,0.900375))

~ dmn1
~ |

PCDemandNew =IF THEN ELSE(SmoothedPercentage>=1,

TotalPCMemoryDensityRequirement*PricesensitivenessDelayedNew

*(1+PCMemoryGrowthRateNew)*SmoothedPercentage,TotalPCMemoryDensityRequirement*

(1+PCMemoryGrowthRateNew)*SmoothedPercentage)

~ widget/Month
~ |

DemandSensitivenessSwitchNew = 0

~ dmn1
~ |

PerceivedFractionalPriceTrendNew = INTEG(ChangeInPerceivedPriceTrendNew
,0)

~ fraction/Month

~ |

TimeToPerceivePriceTrendNew = 18

~ Month

~ |

DemandSensitiveNew f (([-0.1,0.6)-[0.1,1.2)],(-0.1,1.19775)
,(-0.0795876,1.1985),(-0.0197938,1.18127),(-0.0140206,1.16929)
,(-0.00649484,1.14831),(-0.00164948,1.08764),(0,1),(0.00175258,0.944569)
,(0.00412371,0.880899),(0.00814433,0.831461),(0.0202062,0.804494)
,(0.0795876,0.8),(0.0995361,0.795506))

~

~ |

UnitIndex1New = 1

~ Month/fraction

~ |

PricesensitivenessDelayedNew =

DELAY3(PriceSensitivenessOfMemoryDemandNew,6)*0+1

~ dmn1

~ |

HighDemandIndicator = IF THEN ELSE(SUM(TechnologyIndicator[Firm!])>=1,1,0)

~ dmn1

~ |

CapacityGapNew[Firm] = (DesiredCapacityNew[Firm]-
(ConstructionInProgressNew[Firm]-TargetConstructionInProgressNew
[Firm
) * KnowledgeOfConstructionInProgressNew[Firm]-CapacityNew[Firm])

~ widget/Month

~ |

MainstreamDemandNew= HighEndDemand+LowEndDemandNew+PCDemandNew-
DemandNext

~ widget/Month

~ |

DesiredCapacityNew[Firm] =
(DesiredCapacityFromMarketShortageNew[Firm

]+NormalDesiredCapacityNew[Firm])*CapacityNewIndicator[Firm]+
 TechLeaderCapacityBuilding[Firm]
 ~ widget/Month
 ~ |

ChangeInPerceivedPriceTrend = (FractionalTrendInPrice-
 PerceivedFractionalPriceTrend)/
 TimeToPerceivePriceTrend
 ~ fraction/Month/Month
 ~ |

TimeToPerceivePriceTrend = 6
 ~ Month
 ~ |

CapacityNew[Firm] = INTEG(+FinishingConstructionNew[Firm]-RetiringCapacityNew
 [Firm],

DesiredCapacityNew[Firm])
 ~ widget/Month
 ~ |

PricesensitivenessDelayed = DELAY3(PriceSensitivenessOfMemoryDemand,3)
 ~ dmn1
 ~ |

PerceivedFractionalPriceTrend = INTEG(ChangeInPerceivedPriceTrend
 ,0)
 ~ fraction/Month
 ~ |

DemandSensitive f ((-0.1,0.8)-(-0.1,1.3)],(-0.1,1.18764)
 ,(-0.0402062,1.18764),(-0.021134,1.17865),(-0.00649484,1.14831)
 ,(-0.00216495,1.08015),(0,1),(0.0021,0.92),(0.006495,0.852),
 (0.02113,0.821),(0.0402,0.812),(0.1,0.812))
 ~
 ~ |

DemandSensitivenessSwitch = 1
 ~ dmn1
 ~ |

PressueSwitch[Firm] = IF THEN ELSE(SmoothedPercentage>=0.9,1,0)
 ~ dmn1
 ~ |

ChangeInSmoothedPercentage = (PercentageBecomingNew-
SmoothedPercentage)/SmoothingTime

~ dmn1/Month

~ |

SmoothedPercentage = INTEG(ChangeInSmoothedPercentage,0)

~ dmn1

~ |

SmoothingTime = 6

~ Month

~ |

TechLeaderCapacityBuilding[Firm] = DesiredCapacityFromHighEndDemand*
TechnologyIndicator[Firm]

~ widget/dollar

~ |

DesiredCapacityFromHighEndDemand = HighEndUnits/3

~ widget/Month

~ |

YieldSwitch[Firm] = 1

~ dmn1

~ |

IndexOfProductionNew[Firm] = ProductionNew[Firm]/NormalProductionNew[Firm]

~ dmn1

~ |

RnDNew [Firm]= 0

~ dollar/Month

~ |

CostNew [Firm]= VariableCostNew[Firm]+FixedCostNew[Firm]+RnDNew[Firm]

~ dollar/Month

~ |

YieldImprovement f [Firm] ((0,0)-(20000,1)],(0,0)
,(2.57732,0.116105),(10.8247,0.475655),(17.5258,0.666667),(40.2062,0.932584)
,(69.5876,0.955056),(105.67,0.958802),(195.876,0.962547),(376.289,0.958802)
,(979.381,0.962547),(4278.35,0.962547),(39896.9,0.951311))

~ dmn1

~ |

YieldNew [Firm]= YieldImprovement f[Firm](IndexOfCumulativeProductionNew[Firm])
~ dmn1
~ |

NormalCumulativeProductionNew [Firm]=1e+006
~
~ |

IndexOfCumulativeProductionNew [Firm]=
CumulativeProductionNew[Firm]/NormalCumulativeProductionNew[Firm]
]
~ dmn1
~ |

UnitVariableCostNew[Firm] = NormalVariableCostNew[Firm]*(1-
LearningCurveEffectNew[Firm]*
LearningSwitchNew[Firm])*(1-YieldNew[Firm])*YieldSwitch[Firm]
~ dollar/widget
~ |

MarginIndicator[Firm] = IF THEN
ELSE(Margin[Firm]/NormalTrendInMargin[Firm]>=1,0,1)
~ dmn1
~ |

MarketImbalanceNew =
-PerceivedSupplyDemandBalanceNew
~ widget/Month
~ |

MainstreamSupplyNew = SUM(ProductionNew[Firm!])
~ widget/Month
~ |

PerceivedSupplyDemandBalanceNew =
INTEG(ChangeInPerceivedSupplyDemandBalanceNew,0)
~ widget/Month
~ |

NewCapacityRollOver[Firm] = 0
~ widget/(Month*Month)
~ |

ChangeInPerceivedSupplyDemandBalanceNew = (SupplyDemandBalanceNew-

PerceivedSupplyDemandBalanceNew)/TimeToPerceiveSDBalanceNew
~ widget/Month/Month
~ |

TimeToPerceiveSDBalanceNew = 1
~ Month
~ |

SupplyDemandBalanceNew = MainstreamSupplyNew-MainstreamDemandNew
~ widget/Month
~ |

BacklogNew [Firm]= INTEG(CustomerOrdersNew[Firm]-FulfillingOrdersNew[Firm],0)
~ widget
~ |

CapacityLifeNew [Firm]= 75
~ Month
~ |

CapacityUtilizationRateNew [Firm]= IF THEN
ELSE(CapacityNew[Firm]=0,0,DesiredProductionFromMarketShareNew
[Firm
]/CapacityNew[Firm])
~ dmm1
~ |

ChangeInHistoricalOrdersNew[Firm] = (PerceivedOrdersNew[Firm] -
HistoricalOrdersNew[Firm]) /
DurationOverWhichToCalculateTrendNew[Firm]
~ widget/(Month*Month)
~ |

MaximumShippingNew [Firm]= InventoryNew[Firm]/FastestShippingTimeNew[Firm]
~ widget/Month
~ |

ChangeInHistoricalPriceNew = (PerceivedMarketPriceNew - HistoricalPriceNew) /
DurationToCalculateTrendInPriceNew
~ dollar/(Month*widget)
~ |

ChangeInPerceivedindustryDemandNew =(MainstreamDemandNew-
PerceivedIndustryDemandNew)/TimeToPerceiveDemandNew
~ widget/Month/Month

~ |
 ChangeInUnderlyingMarginNew[Firm] = (MarginNew[Firm]-
 UnderlyingMarginNew[Firm])/TimeToChangeUnderlyingMarginNew
 [
 Firm]
 ~ dmn1/Month
 ~ |
 NormalProductionNew [Firm]= 1e+006
 ~ widget
 ~ |
 ChangeInUnitVariableCostNew[Firm] =(UnitVariableCostNew
 [Firm]-PerceivedUnitVariableCostNew[Firm])
 /TimeToPerceiveCostChangeNew[Firm]
 ~ dollar/(widget*Month)
 ~ |
 ConstructionInProgressNew[Firm] = INTEG(+StartingConstructionNew[Firm]
 -
 FinishingConstructionNew[Firm],RetiringCapacityNew[Firm]*ConstructionTimeNew[Fi
 rm])
 ~ widget/Month
 ~ |
 ConstructionTimeNew[Firm] = 30
 ~ Month
 ~ |
 Cost 1 [Firm]= VariableCost 1[Firm]+FixedCost 1[Firm]+TotalRnD[Firm]
 ~ dollar/Month
 ~ |
 CostPerCapacity 1 [Firm]= 1
 ~ dollar/widget
 ~ |
 CostPerCapacityNew [Firm]= 1
 ~ dollar/widget
 ~ |
 CumulativeProductionNew [Firm]=
 INTEG(+ProductionNew[Firm],InitialCumulativeProductionNew[Firm])
 ~ widget

~ |

IndexOfProduction 1[Firm] = Production[Firm]/NormalCumulativeProduction 1[Firm]

~ dmn1

~ |

CustomerOrdersNew [Firm]=

HighEndOrdersNew[Firm]+PCOrdersNew[Firm]+LowEndOrdersNew[Firm]

~ widget/Month

~ |

DeliveryDelayNew [Firm]= IF THEN ELSE(ShipmentsNew[Firm]=0,1,

BacklogNew[Firm]/ShipmentsNew[Firm])

~ Month

~ |

DemandNext = 0

~ widget/Month

~ |

DesiredCapacityFromMarketShortageNew[Firm] = Manager'sDesiredShareNew

*MarketImbalanceNew*0

~ widget/Month

~ |

DesiredProductionFromMarketShareNew [Firm]= ExtrapolatedProductionNew[Firm]

~ widget/Month

~ |

DesiredShippingNew [Firm]= BacklogNew[Firm]/DesiredShippingTimeNew[Firm]

~ widget/Month

~ |

DesiredShippingTimeNew [Firm]= 1

~ Month

~ |

DirectPressureFromMarketShareNew[FirmUSA] = 0 ~|

DirectPressureFromMarketShareNew[FirmJapan] = 0 ~|

DirectPressureFromMarketShareNew[FirmKorea] = 0

~ dmn1

~ |

DurationOverWhichToCalculateTrendNew[Firm] = 3

~ Month

~ |

DurationToCalculateTrendInPriceNew = 3

~ Month

~ |

EffectOfMaximumShippingOnShippingNew[Firm]

=EffectOfMaximumShippingOnShippingNew f

[Firm](MaxRelativeToDesiredShippingNew

[Firm])

~ dmn1

~ |

EffectOfMaximumShippingOnShippingNew f[Firm] ((0,0)-(1,1),

(0,0),(0.123711,0.0299625),(0.216495,0.0749063),(0.342784,0.224719)

,(0.435567,0.363296),(0.688144,0.872659),(0.814433,0.970037)

,(1,1),(1.5,1),(1000,1))

~ dmn1

~ |

ExtrapolatedOrdersNew [Firm]= MAX(0,PerceivedOrdersNew[Firm]*

(1+FractionalTrendInOrdersNew[Firm]*

(TimeToPerceiveOrdersNew[Firm]+ForecastHorizonNew[Firm])))

~ widget/Month

~ |

FastestShippingTimeNew[Firm] = 1

~ Month

~ |

FinishingConstructionNew[Firm] =

ConstructionInProgressNew[Firm]/ConstructionTimeNew[Firm]

~ widget/Month/Month

~ |

Profit 1 [Firm]= Revenue 1[Firm]-Cost 1[Firm]

~ dollar/Month

~ |

FirmPriceIndexNew [Firm]= 1/PriceNew[Firm]

~ widget/dollar

~ |

FixedCost 1[Firm] = Capacity[Firm]*CostPerCapacity 1[Firm]

~ dollar/Month

~ |
 FixedCostNew[Firm] = CapacityNew[Firm]*CostPerCapacityNew[Firm]
 ~ dollar/Month
 ~ |
 ForecastHorizonForProductionNew [Firm]= 1
 ~ Month
 ~ |
 ForecastHorizonNew[Firm] = 24
 ~ Month
 ~ |
 FractionalTrendInOrdersNew [Firm]= IF THEN ELSE(HistoricalOrdersNew[Firm]=0,0,
 (PerceivedOrdersNew [Firm]- HistoricalOrdersNew[Firm]) /
 (HistoricalOrdersNew[Firm] *
 DurationOverWhichToCalculateTrendNew[Firm]))
 ~ fraction/Month
 ~ |
 NormalDesiredCapacityNew[Firm] = ExtrapolatedOrdersNew[Firm]
 ~ widget/Month
 ~ |
 FractionalTrendInPriceNew = IF THEN ELSE(Time<=20,0,
 (PerceivedMarketPriceNew - HistoricalPriceNew) /
 (HistoricalPriceNew * DurationToCalculateTrendInPriceNew))
 ~ fraction/Month
 ~ |
 FulfillingOrdersNew[Firm] = ShipmentsNew[Firm]
 ~ widget/Month
 ~ |
 HighEndUnitsNew = 500000
 ~ widget/Month
 ~ |
 HistoricalOrdersNew [Firm]= INTEG(ChangeInHistoricalOrdersNew[Firm],
 PerceivedOrdersNew[Firm])
 ~ widget/Month
 ~ |
 HistoricalPriceNew = INTEG(ChangeInHistoricalPriceNew, PerceivedMarketPriceNew)

~ dollar/widget

~ |

InitialCumulativeProductionNew[Firm] = 0

~ widget

~ |

InitialInventoryNew[Firm] = 0

~ widget

~ |

InitialMarginNew = 4

~ dmn1

~ |

TimeToPerceiveMarketPriceNew = 1

~ year

~ |

InventoryNew[Firm] = INTEG(ProducingNew[Firm]-
ShipmentsNew[Firm],InitialInventoryNew[Firm])

~ widget

~ |

KnowledgeOfConstructionInProgressNew[Firm] = 1

~ dmn1

~ |

LearningCurveEffectNew[Firm] = LearningCurveEffectNew f[Firm]
(IndexOfProductionNew[Firm])*0

~ dmn1

~ |

LearningCurveEffect 1[Firm] = LearningCurveEffect f 1[Firm](IndexOfProduction
1[Firm])*0

~ dmn1

~ |

LearningCurveEffect f 1 [Firm] (
[(0,0)-(100,1)],(0,0.05),(20,0.05),(30,0.075),(40,0.1),(50,0.115)
,(60,0.117),(100,0.117))

~ dmn1

~ |

LearningCurveEffectNew f [Firm] (

[(0,0)-(50,1)],(0,0.05),(20,0.05),(30,0.075),(40,0.1),(50,0.115)
,(60,0.117),(100,0.117))
~ dmnl
~ |

LearningSwitch 1[Firm] = 1
~ dmnl
~ |

LearningSwitchNew[Firm] = 1
~ dmnl
~ |

LowEndDemandNew =LowEndUnitsNew
~ widget/Month
~ |

LowEndOrdersNew[Firm] = LowEndDemandNew*PercentangeOfOrdersNew[Firm]
~ widget/Month
~ |

LowEndUnitsNew =0
~ widget/Month
~ |

PerceivedIndustryDemandNew = INTEG(ChangeInPerceivedindustryDemandNew,0)
~ widget/Month
~ |

Manager'sDesiredShareNew = 1
~ dmnl
~ Managers want to catch the supply shortage by building new capacity
disproportionate to firm's share
of the market.
|

MarginNew[Firm]
=PressureToChangeMarginNew[Firm]*UnderlyingMarginNew[Firm]-
DirectPressureFromMarketShareNew
[Firm
]
~ dmnl
~ |

MarketAveragePriceNew 0 = SUM(PriceNew 0[Firm!])

~ dollar/widget
~ |

MarketPriceIndexNew =
1/PriceNew[FirmJapan]+1/PriceNew[FirmKorea]+1/PriceNew[FirmUSA]
~ widget/dollar
~ |

RelativeCapacityUtilizationRateNew[Firm] =
CapacityUtilizationRateNew[Firm]/NormalCapacityUtilizationRateNew
[
Firm]
~ dmn1
~ |

MaxRelativeToDesiredShippingNew [Firm]= IF THEN
ELSE(DesiredShippingNew[Firm]=0,0,MaximumShippingNew
[Firm]/DesiredShippingNew
[Firm])
~ dmn1
~ |

NormalCapacityUtilizationRateNew[Firm] = 1
~ dmn1
~ |

NormalCumulativeProduction 1 [Firm]= 1e+006
~ widget
~ |

Revenue 1 [Firm]= Price[Firm]*Shipments[Firm]
~ dollar/Month
~ |

NormalVariableCost 1[Firm] = 10
~ dollar/widget
~ |

NormalVariableCostNew[Firm] = 100
~ dollar/widget
~ |

PCDemandNew f 0 ((0,0)-(400,1)],(0,1),(40,1),(73.1959,0.992509)
,(89.6907,0.992509),(110.309,0.966292),(124.742,0.925094),(144.33,0.7603)
,(157.732,0.168539),(213.402,0.0374532),(260.825,0.0224719),

(302.062,0.0149813),(398.969,0.00374532))

~ dmn1

~ |

PCIndustryGrowthRateNew = 0

~ dmn1

~ |

PCMemoryGrowthRateNew =PCIndustryGrowthRateNew*0

~ dmn1

~ |

PerceivedCapacityUtilizationRateNew[Firm] = INTEG(ChangeInCURateNew[Firm]
,1)

~ dmn1

~ |

PerceivedMarketPriceNew = SMOOTH(MarketAveragePriceNew,
TimeToPerceiveMarketPriceNew)

~ dollar/widget

~ |

TimeToPerceiveDemandNew = 1

~ Month

~ |

PerceivedUnitVariableCostNew[Firm] =
INTEG(ChangeInUnitVariableCostNew[Firm],100)

~ dollar/widget

~ |

PercentageAdjustmentFromCapacityUtilizationNew[Firm] =
PercentageAdjustmentFromCapacityUtilizationNew f
[Firm
(RelativeCapacityUtilizationRateNew[Firm])

~ dmn1

~ |

PercentageAdjustmentFromCapacityUtilizationNew f [Firm] ((

[(0,0)-(10000,10000)],(0,0),(0.231959,0.071161),(0.430412,0.183521)
,(0.525773,0.426966),(0.592784,0.764045),(0.706186,0.940075)
,(1,1),(2,2),(500,500),(596.907,596.9),(1000,1000),(10000,10000)

)

~ dmn1

~ |

PercentageBecomingNew 0 =PCDemandNew f 0(RelativePriceIndex 0)*0
 ~ dmnl
 ~ |

PercentangeOfOrdersNew [Firm]= FirmPriceIndexNew[Firm]/MarketPriceIndexNew
 ~ fraction
 ~ |

PressureFromCUNew f[Firm] ((0,-0.1)-(2,0.1)],
 (0.00515464,0.0370786),(0.417526,0.0303371),(0.628866,0.0235955)
 ,(0.819588,0.0101124),(1,0),(1.49485,-0.0131086),(7.73196,-0.0213483)
 ,(28.3505,-0.0235955),(199.485,-0.0258427),(298.454,-0.0258427)
 ,(401.031,-0.0265918))
 ~ dmnl
 ~ |

UnitVariableCost 1[Firm] = NormalVariableCost 1[Firm]*(1-LearningCurveEffect
 1[Firm]*
 LearningSwitch 1[Firm])
 ~ dollar/widget
 ~ |

PriceNew[Firm] =PerceivedUnitVariableCostNew[Firm]*(1+MarginNew[Firm])
 ~ dollar/widget
 ~ |

PriceNew 0[Firm] =50
 ~ dollar/widget
 ~ |

VariableCostNew[Firm] = ProductionNew[Firm]*UnitVariableCostNew[Firm]
 ~ dollar/Month
 ~ |

RetiringCapacityNew [Firm]= CapacityNew[Firm]
 /CapacityLifeNew[Firm]
 ~ widget/(Month*Month)
 ~ |

TimeToChangeUnderlyingMarginNew[Firm] = 1
 ~ Month
 ~ |

ProducingNew[Firm] = ProductionNew[Firm]

~ widget/Month
~ |

ProductionNew[Firm] = IF THEN
ELSE(CapacityNew[Firm] >= DesiredProductionFromCUNew[Firm],
DesiredProductionFromCUNew[Firm], CapacityNew
[Firm])
~ widget/Month
~ |

TimeToPerceiveCURateNew [Firm] = 1
~ Month
~ |

ProfitNew [Firm] = RevenueNew[Firm] - CostNew[Firm]
~ dollar/Month
~ |

StartingConstructionNew[Firm]
= RetiringCapacityNew[Firm] + CapacityGapNew[Firm] / TimeToStartConstructionNew
[Firm
]
~ widget/(Month*Month)
~ |

RelativePriceIndex 0 = MarketAveragePriceNew 0 / MarketAveragePrice
~ dmn1
~ |

TimeToStartConstructionNew[Firm] = 1
~ Month
~ |

ShipmentsNew[Firm] =
EffectOfMaximumShippingOnShippingNew[Firm] * DesiredShippingNew[Firm]
~ widget/Month
~ |

UnderlyingMarginNew[Firm] = INTEG(ChangeInUnderlyingMarginNew[Firm]
, InitialMarginNew)
~ dmn1
~ |

RevenueNew [Firm] = PriceNew[Firm] * ShipmentsNew[Firm]
~ dollar/Month

~ |

TargetConstructionInProgressNew [Firm]=
(DesiredCapacityNew[Firm]/CapacityLifeNew[Firm])*ConstructionTimeNew
[Firm
]

~ widget/Month

~ |

TimeToPerceiveOrdersNew[Firm] = 1

~ Month

~ |

TimeToPerceiveCostChangeNew [Firm]= 1

~ Month

~ |

VariableCost 1[Firm] = Production[Firm]*UnitVariableCost 1[Firm]

~ dollar/Month

~ |

ChangeInHistoricalPrice = (PerceivedMarketPrice - HistoricalPrice) /
DurationToCalculateTrendInPrice

~ dollar/(Month*widget)

~ |

FractionalTrendInPrice = IF THEN ELSE(Time<=20,0,
(PerceivedMarketPrice - HistoricalPrice) /
(HistoricalPrice * DurationToCalculateTrendInPrice))

~ fraction/Month

~ |

HistoricalPrice = INTEG(ChangeInHistoricalPrice, PerceivedMarketPrice)

~ dollar/widget

~ |

DurationToCalculateTrendInPrice = 3

~ Month

~ |

PerceivedMarketPrice = SMOOTH(MarketAveragePrice, TimeToPerceiveMarketPrice)

~ dollar/widget

~ |

TimeToPerceiveMarketPrice = 3

~ year
~ |

RevenueEarning[Firm] = Revenue[Firm]
~ dollar/Month
~ |

CumulativeRevenue [Firm]= INTEG(RevenueEarning[Firm],0)
~ dollar
~ |

ChangeInUnitVariableCost[Firm] =(UnitVariableCost[Firm]-
PerceivedUnitVariableCost[Firm])
/TimeToPerceiveCostChange[Firm]
~ dollar/(widget*Month)
~ |

PerceivedUnitVariableCost[FirmUSA] =
INTEG(ChangeInUnitVariableCost[FirmUSA],10) ~|
PerceivedUnitVariableCost[FirmJapan] =
INTEG(ChangeInUnitVariableCost[FirmJapan],10) ~|
PerceivedUnitVariableCost[FirmKorea] =
INTEG(ChangeInUnitVariableCost[FirmKorea],10)
~ dollar/widget
~ |

TimeToPerceiveCostChange [Firm]= 1
~ Month
~ |

UnitIndex1 = 1
~ Month/fraction
~ |

UnitIndex 0 [Firm]= 1
~ Month/fraction
~ |

Firm : FirmUSA, FirmJapan, FirmKorea
~
~ different DRAM suppliers in the model
|

InitialPerceivedBacklog[Firm] = 12
~ widget

~ |
 SAVEPER = 1
 ~ Month
 ~ |

 .Capacity
 *****~
 |

DesiredCapacity[Firm] =IF THEN ELSE(SmoothedCapacityIndicator[Firm]>=0.99,0,
 DesiredCapacityFromMarketImbalance[Firm
]+NormalDesiredCapacity[Firm])
 ~ widget/Month
 ~ |

Capacity[Firm] = INTEG(FinishingConstruction[Firm]-RetiringCapacity[Firm],
 DesiredCapacity[Firm])
 ~ widget/Month
 ~ |

DesiredCapacityFromMarketImbalance[FirmKorea] = Manager'sDesiredShare
 *MarketImbalance ~~|
 DesiredCapacityFromMarketImbalance[FirmJapan] = Manager'sDesiredShare
 *MarketImbalance*0 ~~|
 DesiredCapacityFromMarketImbalance[FirmUSA] =
 Manager'sDesiredShare*MarketImbalance*0
 ~ widget/Month
 ~ |

RetiringCapacity [Firm]= Capacity[Firm]
 /CapacityLife[Firm]
 ~ widget/(Month*Month)
 ~ |

MarketImbalance =IF THEN ELSE(PerceivedSupplyDemandBalance>0,0,
 -PerceivedSupplyDemandBalance)*0-PerceivedSupplyDemandBalance
 ~ widget/Month
 ~ |

CapacityGap[Firm] = DesiredCapacity[Firm]-(ConstructionInProgress[Firm]-
 TargetConstructionInProgress[Firm
])*KnowledgeOfConstructionInProgress[Firm]-Capacity[Firm]
 ~ widget/Month

~ |

CapacityLife [Firm]= 75

~ Month

~ |

ChangeInHistoricalOrders[Firm] = (PerceivedOrders[Firm] - HistoricalOrders[Firm]) /
DurationOverWhichToCalculateTrend[Firm]

~ widget/(Month*Month)

~ |

ConstructionInProgress[Firm] = INTEG(+StartingConstruction[Firm]
-FinishingConstruction[Firm],RetiringCapacity[Firm]*ConstructionTime[Firm])

~ widget/Month

~ |

ConstructionTime[Firm] = 30

~ Month

~ |

DurationOverWhichToCalculateTrend[Firm] = 3

~ Month

~ |

ExtrapolatedOrders [Firm]= PerceivedOrders[Firm]*(1+FractionalTrendInOrders[Firm]*
(TimeToPerceiveOrders[Firm]+ForecastHorizon[Firm]))

~ widget/Month

~ |

FinishingConstruction[Firm] = ConstructionInProgress[Firm]/ConstructionTime[Firm]

~ widget/Month/Month

~ |

ForecastHorizon[Firm] = 12

~ Month

~ |

FractionalTrendInOrders [Firm]= (PerceivedOrders [Firm]- HistoricalOrders[Firm]) /
(HistoricalOrders[Firm] * DurationOverWhichToCalculateTrend[Firm])

~ fraction/Month

~ |

HistoricalOrders [Firm]= INTEG(ChangeInHistoricalOrders[Firm],
PerceivedOrders[Firm])

~ widget/Month

~ |

TimeToPerceiveOrders[Firm] = 1

~ Month

~ |

KnowledgeOfConstructionInProgress[Firm] = 1

~ dmn1

~ |

Manager'sDesiredShare = 1

~ dmn1

~ Managers want to catch the supply shortage by building new capacity disproportionate to firm's share of the market.

|

NormalDesiredCapacity[Firm] = ExtrapolatedOrders[Firm]

~ widget/Month

~ |

PerceivedOrders [Firm]= SMOOTH(CustomerOrders[Firm], TimeToPerceiveOrders[Firm])

~ widget/Month

~ |

TargetConstructionInProgress [Firm]= (DesiredCapacity[Firm]/CapacityLife[Firm])*ConstructionTime[Firm]

]

~ widget/Month

~ |

StartingConstruction[Firm] = RetiringCapacity[Firm]+CapacityGap[Firm]/TimeToStartConstruction[Firm]

]

~ widget/(Month*Month)

~ |

TimeToStartConstruction[Firm] = 1

~ Month

~ |

.Price

*****~

PressureFromCU[Firm] =
 PressureFromCU f[Firm](PerceivedCapacityUtilizationSignal[Firm])*0+
 PressureFromCU1 f(PerceivedCapacityUtilizationSignal[Firm])

~ dmn1
 ~ When capacity utilization rate is below unit, managers cut price as a response to overcapacity.

ChangeInCUSignal [Firm]= (CapacityUtilizationSignal[Firm]
 -PerceivedCapacityUtilizationSignal[Firm])/
 TimeToPerceiveCUSignal[Firm]

~ dmn1/Month
 ~ |

PressureToChangeMargin[Firm] = 1
 -PressureFromCU[Firm]

~ dmn1
 ~ |

Price[Firm] =PerceivedUnitVariableCost[Firm]*(1+Margin[Firm])

~ dollar/widget
 ~ |

DirectPressureFromMarketShare[FirmUSA] =0 ~|
 DirectPressureFromMarketShare[FirmJapan] = 0.002*0 ~|
 DirectPressureFromMarketShare[FirmKorea] = 0.004*0

~ dmn1
 ~ |

Margin[Firm] =PressureToChangeMargin[Firm]*UnderlyingMargin[Firm]-
 DirectPressureFromMarketShare[Firm]

] ~ dmn1
 ~ |

PerceivedCapacityUtilizationSignal[Firm] = INTEG(ChangeInCUSignal[Firm]
 ,1)

~ dmn1
 ~ |

PressureFromCU f[Firm] ((0,-0.1)-(2,0.1)],
 (0,0.016859),(0.00773196,0.0168539),(0.425258,0.017603),(0.765464,0.0146067)
 ,(1,0),(1.25258,-0.00786517),(1.65464,-0.00936329),(2.31186,-0.00936329)

,(2.99227,-0.00936329),(297.68,-0.0101124))

~ dmn1

~ |

UnderlyingMargin[Firm] = INTEG(ChangeInUnderlyingMargin[Firm]
,InitialMargin[Firm])

~ dmn1

~ |

TimeToPerceiveCUSignal [Firm]= 3

~ Month

~ |

ChangeInUnderlyingMargin[Firm] = (Margin[Firm]-
UnderlyingMargin[Firm])/TimeToChangeUnderlyingMargin[
Firm]

~ dmn1/Month

~ |

InitialMargin [FirmUSA]= 2 ~|

InitialMargin[FirmKorea] = 2 ~|

InitialMargin[FirmJapan] = 2

~ dmn1

~ |

TimeToChangeUnderlyingMargin[Firm] = 1

~ Month

~ |

UnitIndex [Firm]= 1

~ Month/fraction

~ |

.Demand

*****~

|

HighEndDemand = HighEndUnits*HighEndDeamandIndicatorDelayed

~ widget/Month

~ |

RelativePriceIndex =IF THEN

ELSE(Time<=100,MarketAveragePriceNew/MarketAveragePrice,4)

~ dmn1

PercentageBecomingNew =IF THEN ELSE(Time<=20,0,PCDemandNew
f(RelativePriceIndex))

~ dmn1

~ |

PCDemand =
TotalPCMemoryDensityRequirement*PricesensitivenessDelayed

(1+PCMemoryGrowthRate)(1-SmoothedPercentage*0)

~ widget/Month

~ |

TotalDemand= LowEndDemand+PCDemand

~ widget/Month

~ |

PriceSensitivenessOfMemoryDemand = IF THEN ELSE(DemandSensitivenessSwitch=1,
DemandSensitive f(PerceivedFractionalPriceTrend*UnitIndex1),
Demand f(PerceivedFractionalPriceTrend))

~ dmn1

~ |

MarketAveragePriceNew = SUM(PriceNew[Firm!])/3

~ dollar/widget

~ |

PCMemoryGrowthRate =PCIndustryGrowthRate*0

~ dmn1

~ |

Demand f
(((-0.06,0.8)-(0.06,1.2]),
(-0.0587629,1.09363),(-0.0528866,1.09513),(-0.0389691,1.08165)
,(-0.016701,1.05468),(-0.00773196,1.03221),(0,1),(0.001,1),(0.0105155,0.969288)
,(0.0198454,0.925843),(0.0497423,0.900375),(0.0596907,0.900375)
)

~ dmn1

~ |

LowEndUnits =100000

~ widget/Month

~ |

PCIndustryGrowthRate = 0

~ dmn1
~ |

ChangeInPerceivedindustryDemand =(TotalDemand-
PerceivedIndustryDemand)/TimeToPerceiveDemand
~ widget/Month/Month
~ |

PerceivedIndustryDemand = INTEG(ChangeInPerceivedindustryDemand,0)
~ widget/Month
~ |

LowEndDemand =LowEndUnits
~ widget/Month
~ |

PCDemandNew f ((0,0)-(20,1)],(0,1),(1,1),(2.70619,1)
,(3.32474,1),(3.99485,1),(4,1),(4.53608,0.7539),(4.69072,0.576779)
,(5,0),(6.49485,0),(9.02062,0),(13.1443,0),(25.2577,0),(100,0)
)
~ dmn1
~ |

TotalPCMemoryDensityRequirement = 1e+008-
step(2e+007,60)
~ widget/Month
~ |

TimeToPerceiveDemand = 1
~ Month
~ |

HighEndUnits = 1e+007
~ widget/Month
~ |

.Financial
*****~
|

UnitVariableCost[Firm] = A FUNCTION OF(
CostEffectFromCP, LearningSwitch, NormalVariableCost) ~|
UnitVariableCost[Firm] = NormalVariableCost[Firm]*(1-CostEffectFromCP[Firm]*
LearningSwitch[Firm])

~ dollar/widget

~ |

Profit [Firm]=Revenue[Firm]-Cost[Firm]

~ dollar/Month

~ |

IndexOfProduction[Firm] = Production[Firm]/NormalCumulativeProduction[Firm]

~ dmn1

~ |

LearningSwitch[FirmKorea] = 0 ~|

LearningSwitch[FirmJapan] = 0 ~|

LearningSwitch[FirmUSA] = 0

~ dmn1

~ |

FixedCost[Firm] = Capacity[Firm]*CostPerCapacity[Firm]

~ dollar/Month

~ |

CostPerCapacity [Firm]= 1

~ dollar/widget

~ |

Cost [Firm]= VariableCost[Firm]+FixedCost[Firm]+TotalRnD[Firm]

~ dollar/Month

~ |

CostEffectFromCP[Firm] =CostEffectFromCP f[Firm](IndexOfProduction[Firm])

~ dmn1

~ |

NormalCumulativeProduction [Firm]= 1e+006

~ widget

~ |

Revenue [Firm]= Price[Firm]*Shipments[Firm]

~ dollar/Month

~ |

CostEffectFromCP f [FirmKorea] (

[(0,0)-(100,1)],(0,0.05),(20,0.05),(30,0.075),(40,0.1),(50,0.115)

,(60,0.117),(100,0.117)) ~|

CostEffectFromCP f[FirmJapan] [(0,0)-(100,10)],(0,0),(100,0)

) ~|
 CostEffectFromCP f[FirmUSA] ((0,0)-(100,10)],(0,0),(100,0)
)
 ~ dmn1
 ~ |

NormalVariableCost[Firm] = 10
 ~ dollar/widget
 ~ |

VariableCost[Firm] = Production[Firm]*UnitVariableCost[Firm]
 ~ dollar/Month
 ~ |

.Marketplace
 *****~
 |

MarketShareFromRevenue[Firm] = IF THEN ELSE(CumulativeIndustryRevenue=0,0,
 CumulativeRevenue[Firm]/CumulativeIndustryRevenue)
 ~ fraction
 ~ |

CumulativeIndustryRevenue = SUM(CumulativeRevenue[Firm!])
 ~ dollar
 ~ |

MarketAveragePrice =
 (Price[FirmUSA]+Price[FirmUSA]+Price[FirmKorea])/NumberOfFirms
 ~ dollar/widget
 ~ |

ChangeInPerceivedSupplyDemandBalance = (SupplyDemandBalance-
 PerceivedSupplyDemandBalance)/TimeToPerceiveSDBalance
 ~ widget/Month/Month
 ~ |

IndustryShipments = SUM(Shipments[Firm!])
 ~ widget/Month
 ~ |

MainstreamSupply =
 Production[FirmUSA]+Production[FirmJapan]+Production[FirmKorea]
 ~ widget/Month

~ |

MarketShareFromShipment [Firm]= IF THEN ELSE(IndustryShipments=0,0,
Shipments[Firm]/IndustryShipments)

~ fraction

~ |

SupplyDemandBalance = MainstreamSupply-TotalDemand

~ widget/Month

~ |

NumberOfFirms = 3

~ dmdl

~ |

PerceivedSupplyDemandBalance =
INTEG(ChangeInPerceivedSupplyDemandBalance,0)

~ widget/Month

~ |

TimeToPerceiveSDBalance = 1

~ Month

~ |

.Sales

*****~

|

MarketPriceIndex =

Price[FirmJapan]^ElasticityFactor+Price[FirmKorea]^ElasticityFactor
+Price[FirmUSA]^ElasticityFactor

~ widget/dollar

~ |

PCOrders [Firm]= PCDemand*PercentageOfOrders[Firm]

~ widget/Month

~ |

Backlog [Firm]= INTEG(CustomerOrders[Firm]-FulfillingOrders[Firm],0)

~ widget

~ |

LowEndOrders[Firm] = LowEndDemand*PercentageOfOrders[Firm]

~ widget/Month

~ |
 DeliveryDelay [Firm]= IF THEN ELSE(Shipments[Firm]=0,1,
 Backlog[Firm]/Shipments[Firm])
 ~ Month
 ~ |
 CustomerOrders [Firm]= PCOrders[Firm]+LowEndOrders[Firm]
 ~ widget/Month
 ~ |
 DesiredShipping [Firm]= Backlog[Firm]/DesiredShippingTime[Firm]
 ~ widget/Month
 ~ |
 DesiredShippingTime [Firm]= 1
 ~ Month
 ~ |
 EffectOfMaximumShippingOnShipping[Firm] =IF THEN ELSE(Time<=5,1,
 EffectOfMaximumShippingOnShipping f[Firm])(MaxRelativeToDesiredShipping
 [Firm]))
 ~ dmdl
 ~ |
 EffectOfMaximumShippingOnShipping f[Firm] (
 [(0,0)-(1,1)],(0,0),(0.177835,0.0524344),(0.262887,0.168539)
 ,(0.471649,0.59176),(0.652062,0.910112),(0.757732,0.970037),
 (1,1),(9.97423,0.996255),(600,1))
 ~ dmdl
 ~ |
 FastestShippingTime[Firm] = 1
 ~ Month
 ~ |
 FirmPriceIndex [Firm]= Price[Firm]^ElasticityFactor
 ~ widget/dollar
 ~ |
 FulfillingOrders[Firm] = Shipments[Firm]
 ~ widget/Month
 ~ |
 DesiredInventory[Firm] = 3.33e+007

~ widget
~ |

Inventory[Firm] = INTEG(Producing[Firm]-Shipments[Firm],DesiredInventory[Firm])
~ widget
~ |

MaximumShipping [Firm]= Inventory[Firm]/FastestShippingTime[Firm]
~ widget/Month
~ |

MaxRelativeToDesiredShipping [Firm]= IF THEN
ELSE(DesiredShipping[Firm]=0,0,MaximumShipping[Firm]/DesiredShipping
[Firm])
~ dmdl
~ |

Producing[Firm] = Production[Firm]
~ widget/Month
~ |

PercentageOfOrders [Firm]= FirmPriceIndex[Firm]/MarketPriceIndex
~ fraction
~ |

Shipments[Firm] =
EffectOfMaximumShippingOnShipping[Firm]*DesiredShipping[Firm]
~ widget/Month
~ |

.Production
*****~
|

Production[Firm] =IF THEN ELSE(Capacity[Firm]<=DesiredProductionFromCU[Firm],
Capacity[Firm],DesiredProductionFromCU[Firm])
~ widget/Month
~ |

DesiredProductionFromCU[FirmJapan] =
PercentageAdjustmentFromCapacityUtilization[FirmJapan]*
Capacity[FirmJapan]*0+DesiredProductionFromMarketShare[FirmJapan] ~~|
DesiredProductionFromCU[FirmKorea] = Capacity[FirmKorea]*
PercentageAdjustmentFromCapacityUtilization[FirmKorea]*0+

DesiredProductionFromMarketShare[FirmKorea] ~|
 DesiredProductionFromCU[FirmUSA] = Capacity[FirmUSA]*
 PercentageAdjustmentFromCapacityUtilization[FirmUSA]*0+
 DesiredProductionFromMarketShare[FirmUSA]
 ~ widget/Month
 ~ |

ExtrapolatedProduction[Firm] =MAX(PerceivedOrders[Firm]*(1+
 FractionalTrendInOrders[Firm]*(
 TimeToPerceiveOrders[Firm]+ForecastHorizonForProduction[Firm])),0)
 ~ widget/Month
 ~ |

ForecastHorizonForProduction [Firm]= 1
 ~ Month
 ~ |

DesiredProductionFromMarketShare [Firm]= ExtrapolatedProduction[Firm]
 ~ widget/Month
 ~ |

CapacityUtilizationRate [Firm]= IF THEN
 ELSE(Capacity[Firm]=0,0,DesiredProductionFromMarketShare[Firm
]/Capacity[Firm])
 ~ dmn1
 ~ |

NormalCapacityUtilizationRate[Firm] = 1
 ~ dmn1
 ~ |

PercentageAdjustmentFromCapacityUtilization[FirmJapan] =
 PercentageAdjustmentFromCU f[FirmJapan
]
 (RelativeCapacityUtilizationRate[FirmJapan])*0+RelativeCapacityUtilizationRate[FirmJ
 apan] ~|
 PercentageAdjustmentFromCapacityUtilization[FirmKorea] =
 PercentageAdjustmentFromCU
 f[FirmKorea](RelativeCapacityUtilizationRate[FirmKorea])*0+
 RelativeCapacityUtilizationRate[FirmKorea] ~|
 PercentageAdjustmentFromCapacityUtilization[FirmUSA] =
 PercentageAdjustmentFromCU
 f[FirmUSA](RelativeCapacityUtilizationRate[FirmUSA])*0+
 RelativeCapacityUtilizationRate[FirmUSA]
 ~ dmn1

CostOfTechnology [Firm]= 1e+009

~ dollar/dmnl

~ |

CumulativeRnD[Firm] = INTEG(TatalRnDSpending[Firm],0)

~ dollar

~ |

TotalRnDSpending [Firm]=TotalRnD[Firm]

~ dollar/Month

~ |

RnDSupportFromOutside[Firm] = 0

~ dollar/Month

~ |

TechnologyIndicator[Firm] = IF THEN ELSE(
CumulativeRnD[Firm]/CostOfTechnology[Firm]>1,1,0)*0

~ dmnl

~ |

TotalRnD [Firm]= RnDSupportFromOutside[Firm]+RnDSupportFromWithin[Firm]

~ dollar/Month

~ |

.Control

*****~

Simulation Control Paramaters

|

FINAL TIME = 264

~ Month

~ The final time for the simulation.

|

INITIAL TIME = 0

~ Month

~ The initial time for the simulation.

|

TIME STEP = 0.0625

~ Month

~ The time step for the simulation.

\\---// Sketch information - do not modify anything except names

V160 Do not put anything below this section - it will be ignored

*Price

\$Times New Roman|12||0-0-0|0-0-0|0-0-0

|0,UnderlyingMargin,395,286,53,35,3,0,0,0,0,-1--1--1,-1--1--1

|1,48,95,288,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1

|2,2,182,292,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1

|3,ChangeInUnderlyingMargin,182,312,111,12,32,0,0,0,0,-1--1--1,-1--1--1

|4,Margin,257,224,31,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|5,Price,142,204,23,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|6,PerceivedUnitVariableCost,74,133,54,30,3,0,0,0,0,-1--1--1,-1--1--1

|7,PressureToChangeMargin,449,180,105,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|8,DirectPressureFromMarketShare,604,102,133,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|9,PressureFromCU1 f,750,148,81,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|10,48,317,124,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1

-11

|12,TimeToChangeUnderlyingMargin,175,434,135,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|13,TimeToPerceiveCostChange,156,35,116,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

-14

-15

-16

|17,2,242,127,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1

|18,ChangeInUnitVariableCost,242,142,108,12,32,0,0,0,-1,0,-1--1--1,-1--1--1

-19

-20

-21

-22

|23,CapacityUtilizationSignal,838,249,115,12,0,1,0,1,-1,0,128-128-128,128-128-128

|24,PressureFromCU,636,197,70,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|25,PressureFromCU f,537,253,76,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

-26

|27,PerceivedCapacityUtilizationSignal,614,344,46,29,3,0,0,0,0,-1--1--1,-1--1--1

|28,48,889,331,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1

|29,2,772,335,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1

|30,ChangeInCUSignal,772,355,77,12,32,0,0,0,-1,0,-1--1--1,-1--1--1

|31,UnitVariableCost,338,63,82,12,0,1,0,1,-1,0,128-128-128,128-128-128

|32,TimeToPerceiveCUSignal,673,467,107,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

-33

-34

-35

-36

-37

-38

-39
-40
-41
-42
-43
-44
-45
-46
-47
-48
-49

|50,InitialMargin,392,441,54,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

-51
-52
-53
-54
-55
-56
-57
-58
-59
-60
-61
-62
-63

>2,0,4,0,0,22,0,-1--1--1,1|(265,292)|
>2,1,68,0,0,22,0,-1--1--1,1|(139,292)|
>7,4,2,0,0,0,0,-1--1--1,1|(330,188)|
>4,2,2,0,0,0,0,-1--1--1,1|(205,237)|
>0,4,2,0,0,0,0,-1--1--1,1|(280,222)|
>4,5,2,0,0,0,0,-1--1--1,1|(177,194)|
>0,3,2,0,0,0,0,-1--1--1,1|(305,312)|
>12,3,2,0,0,0,0,-1--1--1,1|(168,321)|
>50,0,0,0,0,0,0,-1--1--1,1|(392,381)|
>25,24,1,0,0,0,0,-1--1--1,1|(594,212)|
>24,7,1,0,0,0,0,-1--1--1,1|(550,174)|
>29,27,4,0,0,22,0,-1--1--1,1|(713,335)|
>29,28,68,0,0,22,0,-1--1--1,1|(829,335)|
>27,30,1,0,0,0,0,-1--1--1,1|(718,300)|
>32,30,1,0,0,0,0,-1--1--1,1|(764,447)|
>27,24,1,0,0,0,0,-1--1--1,1|(641,255)|
>8,4,1,0,0,0,0,-1--1--1,1|(412,132)|
>17,6,4,0,0,22,0,-1--1--1,1|(182,127)|
>17,10,68,0,0,22,0,-1--1--1,1|(278,127)|
>31,18,1,0,0,0,0,-1--1--1,1|(300,101)|

>13,18,1,0,0,0,0,-1--1--1,1|(218,85)|
 >6,18,1,0,0,0,0,-1--1--1,1|(135,87)|
 >6,5,1,0,0,0,0,-1--1--1,1|(98,198)|
 >23,30,1,0,0,0,0,-1--1--1,1|(820,307)|
 >9,24,0,0,0,0,0,-1--1--1,1|(699,169)|
 \\---// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *Financial
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,Revenue,207,136,36,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |1,Profit,275,65,25,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |2,Shipments,99,213,54,12,0,1,0,1,-1,0,128-128-128,255-255-232
 |3,Price,179,216,34,12,0,1,0,1,-1,0,128-128-128,255-255-232
 |4,Cost,402,117,20,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |5,VariableCost,433,178,55,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |6,TotalRnD,557,127,52,12,0,1,0,1,-1,0,128-128-128,255-255-232
 |7,Production,265,205,56,12,0,1,0,1,-1,0,128-128-128,255-255-232
 |8,UnitVariableCost,440,239,71,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |9,CostEffectFromCP,305,295,77,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |10,NormalVariableCost,820,378,85,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |11,CostEffectFromCP f,111,380,82,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |12,EffectFromProcessInnovation,554,429,119,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |13,FixedCost,593,190,43,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |14,CostPerCapacity,774,280,69,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |15,LearningSwitch,634,357,64,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |16,Production,212,465,56,12,0,1,0,1,-1,0,128-128-128,255-255-232
 -17
 |18,Capacity,656,256,48,12,0,1,0,1,-1,0,128-128-128,255-255-232
 |19,IndexOfProduction,306,367,77,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |20,NormalCumulativeProduction,389,500,120,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 -21
 -22
 -23
 >8,5,2,0,0,0,0,-1--1--1,1|(438,212)|
 >9,8,2,0,0,0,0,-1--1--1,1|(349,254)|
 >7,5,2,0,0,0,0,-1--1--1,1|(321,189)|
 >11,9,2,0,0,0,0,-1--1--1,1|(171,332)|
 >20,19,1,0,0,0,0,-1--1--1,1|(360,432)|
 >19,9,1,0,0,0,0,-1--1--1,1|(299,328)|
 >2,0,1,0,0,0,0,-1--1--1,1|(134,155)|
 >3,0,1,0,0,0,0,-1--1--1,1|(201,180)|
 >5,4,0,0,0,0,0,-1--1--1,1|(420,153)|
 >0,1,1,0,0,0,0,-1--1--1,1|(225,90)|
 >4,1,1,0,0,0,0,-1--1--1,1|(355,79)|
 >6,4,1,0,0,0,0,-1--1--1,1|(483,117)|

>13,4,1,0,0,0,0,-1--1--1,1|(486,137)|
 >18,13,1,0,0,0,0,-1--1--1,1|(634,210)|
 >14,13,1,0,0,0,0,-1--1--1,1|(689,216)|
 >15,8,1,0,0,0,0,-1--1--1,1|(529,271)|
 >16,19,1,0,0,0,0,-1--1--1,1|(235,390)|
 >10,8,1,0,0,0,0,-1--1--1,1|(642,282)|
 \\--// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *Capacity
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,ConstructionInProgress,302,492,51,28,3,0,0,0,0,0,-1--1--1,-1--1--1
 |1,Capacity,576,483,40,20,3,0,0,0,0,0,-1--1--1,-1--1--1
 |2,48,67,479,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |3,48,804,485,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |4,DesiredCapacity,370,307,69,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |5,CapacityGap,332,404,54,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -6
 |7,SmoothedCapacityIndicator,338,183,63,29,3,0,0,0,0,0,-1--1--1,-1--1--1
 |8,48,33,186,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |9,TimeToSmoothCapacity,141,265,98,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |10,DesiredCapacityFromMarketImbalance,532,268,158,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |11,2,122,192,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |12,ChangeInSmoothedCapacityIndicator,122,212,148,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |13,MarketImbalance,712,324,71,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |14,Manager'sDesiredShare,829,410,97,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |15,2,158,482,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |16,StartingConstruction,158,502,83,12,32,0,0,0,0,0,-1--1--1,-1--1--1
 |17,2,449,488,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |18,FinishingConstruction,449,508,89,12,32,0,0,0,0,0,-1--1--1,-1--1--1
 |19,TimeToStartConstruction,164,567,102,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |20,CustomerOrders,632,147,78,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |21,NormalDesiredCapacity,500,184,99,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |22,2,676,485,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |23,RetiringCapacity,676,505,69,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |24,ExtrapolatedOrders,910,66,80,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |25,ForecastHorizon,884,23,68,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |26,KnowledgeOfConstructionInProgress,163,330,146,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |27,CapacityLife,489,402,53,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |28,CapacityNewIndicator,197,128,103,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |29,TargetConstructionInProgress,416,359,116,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |30,ConstructionTime,359,603,73,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -31
 -32
 |33,ConstructionTime,640,404,84,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |34,HistoricalOrders,821,192,40,20,3,0,0,0,0,0,-1--1--1,-1--1--1

|35,48,622,189,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
|36,2,702,191,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|37,ChangeInHistoricalOrders,702,223,48,24,40,0,0,0,0,-1--1--1,-1--1--1
|38,PerceivedOrders,737,96,43,27,3,0,0,0,0,-1--1--1,-1--1--1
|39,TimeToPerceiveOrders,856,111,45,23,8,0,0,0,0,-1--1--1,-1--1--1
|40,DurationOverWhichToCalculateTrend,874,268,64,25,8,0,0,0,0,-1--1--1,-1--1--1
|41,FractionalTrendInOrders,968,126,46,26,8,0,0,0,0,-1--1--1,-1--1--1
|42,PerceivedSupplyDemandBalance,843,364,145,12,0,1,0,1,-1,0,128-128-128,128-128-
128
-43
-44
-45
-46
-47
-48
-49
-50
-51
-52
-53
>40,41,2,0,0,0,0,-1--1--1,1|(915,246)|
>38,34,0,1,0,0,0,-1--1--1,1|(776,142)|
>34,41,1,0,0,0,0,-1--1--1,1|(922,192)|
>38,41,1,0,0,0,0,-1--1--1,1|(827,149)|
>40,37,1,0,0,0,0,-1--1--1,1|(778,283)|
>34,37,2,0,0,0,0,-1--1--1,1|(798,238)|
>38,36,1,0,0,0,0,-1--1--1,1|(701,128)|
>39,38,0,0,0,0,0,-1--1--1,1|(802,104)|
>36,35,68,0,0,22,0,-1--1--1,1|(663,191)|
>36,34,4,0,0,22,0,-1--1--1,1|(744,191)|
>13,10,2,0,0,0,0,-1--1--1,1|(655,290)|
>14,10,2,0,0,0,0,-1--1--1,1|(635,356)|
>15,0,4,0,0,22,0,-1--1--1,1|(207,482)|
>15,2,68,0,0,22,0,-1--1--1,1|(113,482)|
>17,1,4,0,0,22,0,-1--1--1,1|(495,488)|
>17,0,68,0,0,22,0,-1--1--1,1|(398,488)|
>4,5,2,0,0,0,0,-1--1--1,1|(335,359)|
>1,5,2,0,0,0,0,-1--1--1,1|(398,412)|
>19,16,2,0,0,0,0,-1--1--1,1|(178,523)|
>0,5,2,0,0,0,0,-1--1--1,1|(315,431)|
>5,16,1,0,0,0,0,-1--1--1,1|(207,425)|
>30,18,1,0,0,0,0,-1--1--1,1|(440,572)|
>0,18,2,0,0,0,0,-1--1--1,1|(354,546)|
>10,4,1,0,0,0,0,-1--1--1,1|(442,274)|
>22,3,4,0,0,22,0,-1--1--1,1|(739,485)|

>22,1,100,0,0,22,0,-1--1--1,1|(643,485)|
 >20,38,1,0,0,0,0,-1--1--1,1|(646,111)|
 >41,24,0,0,0,0,0,-1--1--1,1|(936,93)|
 >25,24,0,0,0,0,0,-1--1--1,1|(892,38)|
 >38,24,0,0,0,0,0,-1--1--1,1|(803,84)|
 >39,24,0,0,0,0,0,-1--1--1,1|(883,87)|
 >24,21,1,0,0,0,0,-1--1--1,1|(648,82)|
 >1,23,1,0,0,0,0,-1--1--1,1|(616,517)|
 >27,23,0,0,0,0,0,-1--1--1,1|(575,450)|
 >26,5,1,0,0,0,0,-1--1--1,1|(266,348)|
 >27,29,1,0,0,0,0,-1--1--1,1|(454,375)|
 >33,29,1,0,0,0,0,-1--1--1,1|(531,337)|
 >4,29,0,0,0,0,0,-1--1--1,1|(387,327)|
 >29,5,0,0,0,0,0,-1--1--1,1|(380,378)|
 >42,13,1,0,0,0,0,-1--1--1,1|(794,339)|
 >4,1,1,1,0,0,0,-1--1--1,1|(485,432)|
 >30,0,1,0,0,0,0,-1--1--1,1|(328,566)|
 >23,0,1,1,0,0,0,-1--1--1,1|(481,402)|
 >23,16,1,1,0,0,0,-1--1--1,1|(480,643)|
 >21,4,1,0,0,0,0,-1--1--1,1|(422,205)|
 >11,7,4,0,0,22,0,-1--1--1,1|(201,192)|
 >11,8,68,0,0,22,0,-1--1--1,1|(78,192)|
 >7,12,2,0,0,0,0,-1--1--1,1|(258,151)|
 >9,12,0,0,0,0,0,-1--1--1,1|(133,245)|
 >28,11,0,0,0,0,0,-1--1--1,1|(160,158)|
 >7,4,1,0,0,0,0,-1--1--1,1|(328,245)|

\\--// Sketch information - do not modify anything except names

V160 Do not put anything below this section - it will be ignored

*Production

\$Times New Roman|12||0-0-0|0-0-0|0-0-0

|0,InitialCumulativeProduction,629,147,114,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|1,CumulativeProduction,463,62,54,24,3,0,0,0,0,0,-1--1--1,-1--1--1

|2,48,292,64,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1

|3,2,364,64,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1

|4,Production,364,80,45,12,32,0,0,0,-1,0,-1--1--1,-1--1--1

-5

|6,DesiredProductionFromMarketShare,489,338,148,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|7,Capacity,417,127,48,12,0,1,0,1,-1,0,128-128-128,128-128-128

|8,CapacityUtilizationSignal,129,222,104,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

-9

|10,NormalCapacityUtilizationRate,509,295,127,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|11,PerceivedOrders,300,477,81,12,0,1,0,1,-1,0,128-128-128,128-128-128

|12,CapacityUtilizationRate,221,353,97,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|13,PercentageAdjustmentFromCU f,533,224,129,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|14,Capacity,178,442,48,12,0,1,0,1,-1,0,128-128-128,128-128-128

|15,DesiredProductionFromCU,239,126,111,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |16,RelativeCapacityUtilizationRate,298,261,130,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |17,PercentageAdjustmentFromCapacityUtilization,298,168,187,12,0,0,0,0,-1,0,-1--1--1,-
 1--1--1
 |18,FractionalTrendInOrders,364,523,112,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |19,ForecastHorizonForProduction,554,578,125,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |20,ExtrapolatedProduction,485,378,96,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |21,TimeToPerceiveOrders,639,463,107,12,0,1,0,1,-1,0,128-128-128,128-128-128
 >3,1,4,0,0,22,0,-1--1--1,1|(389,64)|
 >3,2,100,0,0,22,0,-1--1--1,1|(329,64)|
 >0,1,2,0,0,0,0,-1--1--1,1|(573,80)|
 >14,12,2,0,0,0,0,-1--1--1,1|(218,376)|
 >6,12,2,0,0,0,0,-1--1--1,1|(334,363)|
 >10,16,1,0,0,0,0,-1--1--1,1|(459,272)|
 >12,16,1,0,0,0,0,-1--1--1,1|(228,285)|
 >16,17,1,0,0,0,0,-1--1--1,1|(274,222)|
 >13,17,1,0,0,0,0,-1--1--1,1|(476,165)|
 >17,15,1,0,0,0,0,-1--1--1,1|(274,154)|
 >11,20,1,0,0,0,0,-1--1--1,1|(400,395)|
 >18,20,1,0,0,0,0,-1--1--1,1|(446,431)|
 >19,20,1,0,0,0,0,-1--1--1,1|(524,441)|
 >21,20,1,0,0,0,0,-1--1--1,1|(545,409)|
 >20,6,0,0,0,0,0,-1--1--1,1|(486,364)|
 >14,15,1,1,0,0,0,-1--1--1,1|(45,294)|
 >6,15,1,1,0,0,0,-1--1--1,1|(491,96)|
 >15,4,1,0,0,0,0,-1--1--1,1|(287,91)|
 >16,8,1,0,0,0,0,-1--1--1,1|(163,241)|
 >17,8,1,0,0,0,0,-1--1--1,1|(193,179)|
 >7,4,1,0,0,0,0,-1--1--1,1|(404,102)|

\\--// Sketch information - do not modify anything except names

V160 Do not put anything below this section - it will be ignored

*Sales

\$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,Backlog,278,351,40,20,3,0,0,0,0,0,-1--1--1,-1--1--1
 |1,48,85,352,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |2,Time,483,597,34,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |3,48,479,348,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |4,PCDemand,58,207,58,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |5,2,161,350,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |6,CustomerOrders,161,370,67,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |7,2,402,348,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |8,FulfillingOrders,402,364,67,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |9,Inventory,295,457,40,20,3,0,0,0,0,0,-1--1--1,-1--1--1
 |10,48,80,458,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |11,Production,62,517,56,12,0,1,0,1,-1,0,128-128-128,128-128-128

|12,48,506,457,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
|13,2,416,457,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|14,Shipments,416,473,43,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
|15,2,134,455,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|16,Producing,134,475,42,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
|17,DesiredShipping,685,395,69,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|18,DesiredShippingTime,539,250,89,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|19,MaximumShipping,239,518,76,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|20,FastestShippingTime,146,605,85,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|21,MaxRelativeToDesiredShipping,401,634,131,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|22,EffectOfMaximumShippingOnShipping,533,561,156,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|23,ElasticityFactor,207,91,65,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
-24
-25
|26,Price,242,55,34,12,0,1,0,1,-1,0,128-128-128,128-128-128
|27,MarketPriceIndex,320,148,73,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|28,DesiredInventory,358,517,71,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|29,FirmPriceIndex,145,151,64,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|30,EffectOfMaximumShippingOnShipping f,652,496,162,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
1
|31,PercentageOfOrders,192,191,87,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|32,PCOrders,142,272,42,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|33,LowEndDemand,311,205,79,12,0,1,0,1,-1,0,128-128-128,128-128-128
-34
|35,LowEndOrders,229,271,63,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|36,DeliveryDelay,304,410,61,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
>5,0,4,0,0,22,0,-1--1--1,1|(202,350)|
>5,1,100,0,0,22,0,-1--1--1,1|(124,350)|
>7,3,4,0,0,22,0,-1--1--1,1|(439,348)|
>7,0,100,0,0,22,0,-1--1--1,1|(357,348)|
>13,12,4,0,0,22,0,-1--1--1,1|(460,457)|
>13,9,100,0,0,22,0,-1--1--1,1|(372,457)|
>15,9,4,0,0,22,0,-1--1--1,1|(197,455)|
>15,10,100,0,0,22,0,-1--1--1,1|(108,455)|
>11,16,2,0,0,0,0,-1--1--1,1|(75,488)|
>14,8,2,0,0,0,0,-1--1--1,1|(391,415)|
>0,17,2,0,0,0,0,-1--1--1,1|(426,286)|
>18,17,2,0,0,0,0,-1--1--1,1|(592,293)|
>17,13,2,0,0,0,0,-1--1--1,1|(500,400)|
>9,19,2,0,0,0,0,-1--1--1,1|(233,503)|
>19,21,1,0,0,0,0,-1--1--1,1|(270,590)|
>21,22,2,0,0,0,0,-1--1--1,1|(382,544)|
>22,14,2,0,0,0,0,-1--1--1,1|(404,497)|
>28,9,0,0,0,0,0,-1--1--1,1|(336,495)|
>20,19,0,0,0,0,0,-1--1--1,1|(186,566)|

>17,21,1,0,0,0,0,-1--1--1,1|(664,597)|
 >30,22,0,0,0,0,0,-1--1--1,1|(598,525)|
 >26,29,1,0,0,0,0,-1--1--1,1|(132,58)|
 >26,27,1,0,0,0,0,-1--1--1,1|(364,60)|
 >29,31,0,0,0,0,0,-1--1--1,1|(162,166)|
 >27,31,0,0,0,0,0,-1--1--1,1|(262,167)|
 >31,32,1,0,0,0,0,-1--1--1,1|(163,222)|
 >32,5,0,0,0,0,0,-1--1--1,1|(149,306)|
 >33,35,1,0,0,0,0,-1--1--1,1|(282,231)|
 >35,5,0,0,0,0,0,-1--1--1,1|(197,307)|
 >0,36,0,0,0,0,0,-1--1--1,1|(289,378)|
 >14,36,1,0,0,0,0,-1--1--1,1|(336,433)|
 >31,35,1,0,0,0,0,-1--1--1,1|(216,225)|
 >2,22,0,0,0,0,0,-1--1--1,1|(501,583)|
 >4,32,0,0,0,0,0,-1--1--1,1|(93,235)|
 >23,29,1,0,0,0,0,-1--1--1,1|(160,105)|
 >23,27,1,0,0,0,0,-1--1--1,1|(285,80)|
 \\---/// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *Demand
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,TotalDemand,377,105,56,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |1,SmoothedPercentage,557,200,95,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |2,PCDemand,384,149,47,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |3,LowEndDemand,633,134,68,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |4,UnitIndex1,435,317,45,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -5
 -6
 |7,TotalPCMemoryDensityRequirement,137,241,148,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |8,PerceivedIndustryDemand,742,37,55,20,3,0,0,0,0,-1--1--1,-1--1--1
 |9,48,245,34,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |10,PCMemoryGrowthRate,468,250,95,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |11,TimeToPerceiveDemand,380,-19,101,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |12,2,448,34,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |13,ChangeInPerceivedindustryDemand,448,50,143,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 -14
 |15,PCIndustryGrowthRate,585,300,94,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |16,PriceSensitivenessOfMemoryDemand,300,270,152,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -17
 |18,PricesensitivenessDelayed,317,224,108,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |19,Time,731,540,34,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |20,DemandSensitive f,221,381,77,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |21,DemandSensitivenessSwitch,134,331,116,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |22,PerceivedFractionalPriceTrend,670,370,59,27,3,0,0,0,0,-1--1--1,-1--1--1
 |23,LowEndUnits,792,228,56,12,0,0,0,0,0,-1--1--1,-1--1--1

|24,48,380,368,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |25,2,469,368,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |26,ChangeInPerceivedPriceTrend,469,384,123,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |27,Demand f,159,376,40,12,0,0,1,0,-1,0,-1--1--1,-1--1--1
 |28,MarketAveragePrice,143,479,96,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |29,HistoricalPrice,539,558,40,20,3,0,0,0,0,-1--1--1,-1--1--1
 |30,48,358,544,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |31,2,432,545,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |32,ChangeInHistoricalPrice,432,577,49,24,40,0,0,0,0,-1--1--1,-1--1--1
 |33,PerceivedMarketPrice,396,474,55,26,3,0,0,0,0,-1--1--1,-1--1--1
 |34,TimeToPerceiveMarketPrice,204,552,52,31,8,0,0,0,0,-1--1--1,-1--1--1
 |35,DurationToCalculateTrendInPrice,643,658,56,23,8,0,0,0,0,-1--1--1,-1--1--1
 |36,FractionalTrendInPrice,550,431,55,20,8,0,0,0,0,-1--1--1,-1--1--1
 |37,TimeToPerceivePriceTrend,420,351,113,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -38

>35,36,2,0,0,0,0,-1--1--1,1|(656,572)|
 >33,29,0,1,0,0,0,-1--1--1,1|(465,515)|
 >29,36,1,0,0,0,0,-1--1--1,1|(573,486)|
 >33,36,1,0,0,0,0,-1--1--1,1|(465,475)|
 >35,32,1,0,0,0,0,-1--1--1,1|(468,692)|
 >29,32,2,0,0,0,0,-1--1--1,1|(511,619)|
 >33,31,1,0,0,0,0,-1--1--1,1|(394,513)|
 >34,33,1,0,0,0,0,-1--1--1,1|(276,559)|
 >31,30,68,0,0,22,0,-1--1--1,1|(396,545)|
 >31,29,4,0,0,22,0,-1--1--1,1|(468,545)|
 >12,8,4,0,0,22,0,-1--1--1,1|(570,34)|
 >12,9,100,0,0,22,0,-1--1--1,1|(347,34)|
 >8,13,2,0,0,0,0,-1--1--1,1|(526,73)|
 >11,12,2,0,0,0,0,-1--1--1,1|(442,0)|
 >0,13,2,0,0,0,0,-1--1--1,1|(407,66)|
 >2,0,2,0,0,0,0,-1--1--1,1|(397,125)|
 >3,0,2,0,0,0,0,-1--1--1,1|(536,103)|
 >23,3,1,0,0,0,0,-1--1--1,1|(694,162)|
 >10,2,0,0,0,0,0,-1--1--1,1|(430,204)|
 >15,10,1,0,0,0,0,-1--1--1,1|(546,260)|
 >7,2,1,0,0,0,0,-1--1--1,1|(265,181)|
 >28,33,0,0,0,0,0,-1--1--1,1|(283,476)|
 >4,16,2,0,0,0,0,-1--1--1,1|(333,310)|
 >19,36,1,0,0,0,0,-1--1--1,1|(656,473)|
 >20,16,0,0,0,0,0,-1--1--1,1|(255,331)|
 >27,16,0,1,0,0,0,-1--1--1,1|(223,327)|
 >21,16,1,0,0,0,0,-1--1--1,1|(189,303)|
 >25,22,4,0,0,22,0,-1--1--1,1|(543,368)|
 >25,24,68,0,0,22,0,-1--1--1,1|(425,368)|
 >36,26,0,0,0,0,0,-1--1--1,1|(508,406)|

>22,26,0,0,0,0,0,-1--1--1,1|(608,374)|
 >37,26,0,0,0,0,0,-1--1--1,1|(438,363)|
 >22,16,1,0,0,0,0,-1--1--1,1|(481,291)|
 >16,18,0,0,0,0,0,-1--1--1,1|(305,253)|
 >18,2,0,0,0,0,0,-1--1--1,1|(345,191)|
 >1,2,0,0,0,0,0,-1--1--1,1|(477,176)|
 \\---// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *Marketplace
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,MarketAveragePrice,125,375,85,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |1,Price,87,444,34,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |2,NumberOfFirms,151,444,67,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |3,TimeToPerceiveSDBalance,240,87,113,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |4,PerceivedSupplyDemandBalance,484,158,64,31,3,0,0,0,0,0,-1--1--1,-1--1--1
 |5,TotalDemand,337,277,67,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |6,MainstreamSupply,174,262,76,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |7,48,128,155,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |8,2,265,154,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |9,ChangeInPerceivedSupplyDemandBalance,265,170,171,12,32,0,0,0,0,0,-1--1--1,-1--1--1
 |10,Production,211,310,56,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |11,SupplyDemandBalance,254,219,94,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |12,MarketShareFromRevenue,725,145,108,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |13,MarketShareFromShipment,790,472,110,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |14,Revenue,627,187,47,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |15,CumulativeIndustryRevenue,965,209,113,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |16,CumulativeRevenue,757,210,55,23,3,0,0,0,0,0,-1--1--1,-1--1--1
 |17,Shipments,718,511,54,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |18,IndustryShipments,859,509,74,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |19,48,556,213,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |20,2,620,213,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |21,RevenueEarning,620,228,67,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |22,MainstreamDemandNew,348,644,111,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |23,Profit,460,360,36,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |24,ProfitNew,513,427,55,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |25,CumulativeProfitNew,600,380,66,25,3,0,0,0,0,0,-1--1--1,-1--1--1
 |26,CumulativeProfitCurrent,602,294,62,24,3,0,0,0,0,0,-1--1--1,-1--1--1
 |27,48,385,291,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |28,48,417,381,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |29,TimeToPerceiveSDBalanceNew,277,405,132,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |30,PerceivedSupplyDemandBalanceNew,553,478,88,33,3,0,0,0,0,0,-1--1--1,-1--1--1
 |31,TotalCumulativeProfit,763,335,91,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |32,MainstreamSupplyNew,183,588,95,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |33,48,159,474,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1

|34,2,269,473,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|35,ChangeInPerceivedSupplyDemandBalanceNew,269,493,190,12,32,0,0,0,0,-1--1--1,-1--1--1
|36,Revenue,586,106,47,12,0,1,0,1,-1,0,128-128-128,128-128-128
|37,SupplyDemandBalanceNew,267,553,113,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|38,ProductionNew,127,650,75,12,0,1,0,1,-1,0,128-128-128,128-128-128
|39,2,467,292,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|40,ProfitEarning,467,307,55,12,32,0,0,0,0,-1--1--1,-1--1--1
|41,2,494,378,5,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|42,ProfitEarningNew,494,393,74,12,32,0,0,0,0,-1--1--1,-1--1--1
|43,IndustryRevenue,714,113,68,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|44,MSFromRevenue,662,50,71,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

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>30,35,1,0,0,0,0,-1--1--1,1|(462,556)|
>37,35,0,0,0,0,0,-1--1--1,1|(268,529)|
>32,37,1,0,0,0,0,-1--1--1,1|(205,566)|
>29,34,2,0,0,0,0,-1--1--1,1|(274,441)|
>34,33,100,0,0,22,0,-1--1--1,1|(215,473)|
>34,30,4,0,0,22,0,-1--1--1,1|(370,473)|
>1,0,1,0,0,0,0,-1--1--1,1|(86,411)|
>8,4,4,0,0,22,0,-1--1--1,1|(345,154)|
>8,7,100,0,0,22,0,-1--1--1,1|(198,154)|
>3,8,2,0,0,0,0,-1--1--1,1|(259,122)|
>10,6,2,0,0,0,0,-1--1--1,1|(194,294)|
>6,11,0,0,0,0,0,-1--1--1,1|(208,243)|
>5,11,0,0,0,0,0,-1--1--1,1|(301,252)|
>11,9,0,0,0,0,0,-1--1--1,1|(258,201)|
>4,9,1,0,0,0,0,-1--1--1,1|(412,210)|
>17,13,0,0,0,0,0,-1--1--1,1|(747,494)|
>17,18,0,0,0,0,0,-1--1--1,1|(771,511)|
>18,13,0,0,0,0,0,-1--1--1,1|(830,493)|
>2,0,1,0,0,0,0,-1--1--1,1|(147,407)|
>20,16,4,0,0,22,0,-1--1--1,1|(664,213)|
>20,19,68,0,0,22,0,-1--1--1,1|(589,213)|
>14,21,0,0,0,0,0,-1--1--1,1|(624,200)|
>16,12,0,0,0,0,0,-1--1--1,1|(741,178)|
>15,12,0,0,0,0,0,-1--1--1,1|(851,178)|
>16,15,0,0,0,0,0,-1--1--1,1|(825,209)|
>38,32,2,0,0,0,0,-1--1--1,1|(135,606)|
>22,37,1,0,0,0,0,-1--1--1,1|(322,592)|
>41,25,4,0,0,22,0,-1--1--1,1|(516,378)|
>41,28,68,0,0,22,0,-1--1--1,1|(457,378)|
>24,41,0,0,0,0,0,-1--1--1,1|(505,406)|
>25,31,0,0,0,0,0,-1--1--1,1|(685,356)|

>36,44,0,0,0,0,0,-1--1--1,1|(617,82)|
 >36,43,0,0,0,0,0,-1--1--1,1|(632,107)|
 >43,44,0,0,0,0,0,-1--1--1,1|(692,86)|
 >39,26,4,0,0,22,0,-1--1--1,1|(506,292)|
 >39,27,68,0,0,22,0,-1--1--1,1|(427,292)|
 >23,40,0,0,0,0,0,-1--1--1,1|(462,340)|
 >26,31,0,0,0,0,0,-1--1--1,1|(682,314)|
 \\---// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *Technology
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,RnDSupportFromWithin,242,170,61,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |1,RnDSupportFromOutside,415,123,63,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |2,MarginIndicator,364,403,40,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |3,PercentageDevotedTo RnD,320,96,66,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |4,TotalRnD,287,198,25,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |5,MarketShareFromShipment,422,47,75,7,0,1,0,1,-1,0,128-128-128,128-128-128
 |6,CumulativeRnD,397,226,40,20,3,0,0,0,0,-1--1--1,-1--1--1
 |7,48,212,237,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |8,2,288,237,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |9,TatalRnDSpending,288,253,47,7,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |10,CostOfTechnology,536,240,47,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |11,TechnologyIndicator,434,301,51,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |12,NormalTrendInMargin,290,359,56,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
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 |14,CapacityNewIndicator,503,357,55,7,0,0,0,0,-1,0,-1--1--1,-1--1--1
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 |29,Margin,281,436,26,7,0,1,0,1,-1,0,128-128-128,128-128-128
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|47,Revenue,173,73,30,7,0,1,0,1,-1,0,128-128-128,128-128-128

>3,0,1,0,0,0,0,-1--1--1,1|(279,144)|

>0,4,0,0,0,0,0,-1--1--1,1|(258,180)|

>1,4,1,0,0,0,0,-1--1--1,1|(382,162)|

>8,6,4,0,0,22,0,-1--1--1,1|(325,237)|

>8,7,100,0,0,22,0,-1--1--1,1|(251,237)|

>4,9,1,0,0,0,0,-1--1--1,1|(263,225)|

>6,11,0,0,0,0,0,-1--1--1,1|(414,263)|

>10,11,0,0,0,0,0,-1--1--1,1|(491,266)|

>11,14,1,0,0,0,0,-1--1--1,1|(485,324)|

>47,0,0,0,0,0,0,-1--1--1,1|(202,115)|

>5,3,0,0,0,0,0,-1--1--1,1|(377,68)|

>29,2,1,0,0,0,0,-1--1--1,1|(329,418)|

>12,2,1,0,0,0,0,-1--1--1,1|(339,381)|

>2,14,1,0,0,0,0,-1--1--1,1|(447,385)|

\\---// Sketch information - do not modify anything except names

V160 Do not put anything below this section - it will be ignored

*PriceNew

\$Times New Roman|12||0-0-0|0-0-0|0-0-0

|0,UnderlyingMarginNew,343,248,69,21,3,0,0,0,0,0,-1--1--1,-1--1--1

|1,48,57,249,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1

|2,2,168,250,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1

|3,ChangeInUnderlyingMarginNew,168,270,130,12,32,0,0,0,0,0,-1--1--1,-1--1--1

|4,MarginNew,272,177,50,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|5,PriceNew,161,162,42,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|6,PerceivedUnitVariableCostNew,92,108,47,26,3,0,0,0,0,0,-1--1--1,-1--1--1

|7,PressureToChangeMarginNew,457,194,124,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|8,DirectPressureFromMarketShareNew,502,142,152,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|9,CUSignalNew,641,300,70,12,0,1,0,1,-1,0,128-128-128,128-128-128

|10,48,344,94,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1

|11,SmoothedPressureSwitch,746,198,103,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|12,TimeToChangeUnderlyingMarginNew,174,392,154,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|13,TimeToPerceiveCostChangeNew,230,54,135,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
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|16,2,269,97,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|17,ChangeInUnitVariableCostNew,269,112,127,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
|18,PressureFromCUNew,505,237,89,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|19,PressureFromCUNew f,479,309,95,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
-20
|21,PerceivedCapacityUtilizationRateNew,547,396,52,30,3,0,0,0,0,-1--1--1,-1--1--1
|22,48,802,392,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
|23,2,701,392,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|24,ChangeInCURateNew,701,407,89,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
-25
|26,TimeToPerceiveCURateNew,665,522,119,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
-27
|28,InitialMarginNew,375,333,73,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
-29
-30
|31,UnitVariableCostNew,509,59,101,12,0,1,0,1,-1,0,128-128-128,128-128-128
|32,PressueSwitch,814,231,60,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|33,SmoothedPercentage,832,274,95,12,0,1,0,1,-1,0,128-128-128,128-128-128
>6,5,0,0,0,0,0,-1--1--1,1|(130,137)|
>6,17,1,0,0,0,0,-1--1--1,1|(169,140)|
>13,17,1,0,0,0,0,-1--1--1,1|(259,93)|
>16,10,68,0,0,22,0,-1--1--1,1|(305,97)|
>16,6,4,0,0,22,0,-1--1--1,1|(201,97)|
>8,4,1,0,0,0,0,-1--1--1,1|(332,151)|
>21,18,1,0,0,0,0,-1--1--1,1|(554,279)|
>26,24,1,0,0,0,0,-1--1--1,1|(718,475)|
>21,24,1,0,0,0,0,-1--1--1,1|(664,341)|
>23,22,68,0,0,22,0,-1--1--1,1|(750,392)|
>23,21,4,0,0,22,0,-1--1--1,1|(647,392)|
>18,7,1,0,0,0,0,-1--1--1,1|(473,209)|
>19,18,1,0,0,0,0,-1--1--1,1|(486,264)|
>28,0,0,0,0,0,0,-1--1--1,1|(363,301)|
>12,3,2,0,0,0,0,-1--1--1,1|(152,296)|
>0,3,2,0,0,0,0,-1--1--1,1|(265,297)|
>4,5,2,0,0,0,0,-1--1--1,1|(204,164)|
>0,4,2,0,0,0,0,-1--1--1,1|(307,192)|
>4,2,2,0,0,0,0,-1--1--1,1|(232,207)|
>7,4,2,0,0,0,0,-1--1--1,1|(312,176)|
>2,1,68,0,0,22,0,-1--1--1,1|(114,250)|
>2,0,4,0,0,22,0,-1--1--1,1|(224,250)|
>31,17,0,0,0,0,0,-1--1--1,1|(395,83)|
>33,32,0,0,0,0,0,-1--1--1,1|(825,258)|

>9,23,0,0,0,0,0,-1--1--1,1|(667,342)|
 >32,11,0,0,0,0,0,-1--1--1,1|(786,217)|
 >11,18,0,0,0,0,0,-1--1--1,1|(632,216)|
 \\--// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *FinancialNew
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,ShipmentsNew,133,181,73,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |1,PriceNew,42,178,53,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |2,CumulativeProductionNew,387,462,120,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |3,IndexOfCumulativeProductioNew,481,358,136,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |4,ProductionNew,210,200,75,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |5,CapacityNew,598,195,67,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |6,NormalCumulativeProductionNew,634,454,139,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |7,RnDNew,415,77,39,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |8,YieldImprovement f,346,354,82,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |9,YieldNew,388,274,44,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |10,YieldSwitch,517,288,52,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |11,ProductionNew,82,418,75,12,0,1,0,1,-1,0,128-128-128,128-128-128
 -12
 -13
 -14
 -15
 -16
 -17
 -18
 |19,RevenueNew,142,118,55,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |20,ProfitNew,226,31,44,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 -21
 -22
 |23,CostNew,273,88,39,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |24,VariableCostNew,320,166,74,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 -25
 -26
 |27,UnitVariableCostNew,389,208,90,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |28,LearningCurveEffectNew,161,262,103,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |29,NormalVariableCostNew,634,244,104,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |30,LearningCurveEffectNew f,75,310,109,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |31,FixedCostNew,452,120,62,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |32,CostPerCapacityNew,623,149,88,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |33,LearningSwitchNew,264,290,83,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 -34
 -35
 |36,IndexOfProductionNew,211,329,96,12,0,0,0,0,-1,0,-1--1--1,255-255-232
 |37,NormalProductionNew,284,419,94,12,0,0,0,0,-1,0,-1--1--1,255-255-232

>33,27,1,0,0,0,0,-1--1--1,1|(312,239)|
 >32,31,1,0,0,0,0,-1--1--1,1|(536,122)|
 >31,23,1,0,0,0,0,-1--1--1,1|(353,88)|
 >23,20,1,0,0,0,0,-1--1--1,1|(257,61)|
 >19,20,1,0,0,0,0,-1--1--1,1|(161,59)|
 >24,23,0,0,0,0,0,-1--1--1,1|(300,132)|
 >36,28,1,0,0,0,0,-1--1--1,1|(187,294)|
 >37,36,1,0,0,0,0,-1--1--1,1|(255,373)|
 >30,28,2,0,0,0,0,-1--1--1,1|(121,279)|
 >29,27,2,0,0,0,0,-1--1--1,1|(434,191)|
 >28,27,2,0,0,0,0,-1--1--1,1|(235,230)|
 >27,24,2,0,0,0,0,-1--1--1,1|(344,186)|
 >0,19,1,0,0,0,0,-1--1--1,1|(151,153)|
 >1,19,1,0,0,0,0,-1--1--1,1|(76,140)|
 >4,24,1,0,0,0,0,-1--1--1,1|(247,170)|
 >5,31,1,0,0,0,0,-1--1--1,1|(525,152)|
 >7,23,1,0,0,0,0,-1--1--1,1|(347,69)|
 >2,3,1,0,0,0,0,-1--1--1,1|(383,424)|
 >6,3,1,0,0,0,0,-1--1--1,1|(610,372)|
 >3,9,1,0,0,0,0,-1--1--1,1|(449,309)|
 >8,9,1,0,0,0,0,-1--1--1,1|(346,313)|
 >9,27,1,0,0,0,0,-1--1--1,1|(388,230)|
 >10,27,1,0,0,0,0,-1--1--1,1|(457,259)|
 >11,36,0,0,0,0,0,-1--1--1,1|(140,377)|
 \\\---/// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *CapacityNew
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,CustomerOrdersNew,628,107,97,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |1,PerceivedSupplyDemandBalanceNew,807,361,164,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |2,CapacityNewIndicator,505,173,103,12,0,1,0,1,-1,0,128-128-128,128-128-128
 -3
 -4
 -5
 |6,HighEndOrdersNew,585,71,94,12,0,1,0,1,-1,0,128-128-128,128-128-128
 -7
 |8,TechLeaderCapacityBuilding,277,166,118,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |9,TechnologyIndicator,189,108,95,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |10,DesiredCapacityFromHighEndDemand,303,74,157,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |11,HighEndUnits,301,7,68,12,0,1,0,1,-1,0,128-128-128,128-128-128
 -12
 -13
 -14
 -15

-16
 -17
 -18
 |19,ConstructionInProgressNew,284,413,56,26,3,0,0,0,0,0,-1--1--1,-1--1--1
 |20,CapacityNew,574,412,40,20,3,0,0,0,0,0,-1--1--1,-1--1--1
 |21,48,44,413,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |22,48,851,406,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |23,DesiredCapacityNew,366,218,88,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |24,CapacityGapNew,317,321,77,13,0,0,0,2,-1,0,Times New Roman|2|B|0-0-0,-1--1--1
 |25,DesiredCapacityFromMarketShortageNew,540,238,171,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -1
 |26,MarketImbalanceNew,843,286,90,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |27,Manager'sDesiredShareNew,672,266,116,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |28,2,135,415,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |29,StartingConstructionNew,135,435,102,12,32,0,0,0,0,0,-1--1--1,-1--1--1
 |30,2,446,410,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |31,FinishingConstructionNew,446,430,108,12,32,0,0,0,0,0,-1--1--1,-1--1--1
 |32,TimeToStartConstructionNew,211,509,121,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -33
 |34,NormalDesiredCapacityNew,464,124,118,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |35,2,708,410,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |36,RetiringCapacityNew,708,430,88,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |37,ExtrapolatedOrdersNew,899,16,99,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |38,ForecastHorizonNew,873,-27,87,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |39,KnowledgeOfConstructionInProgressNew,157,252,165,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 1
 |40,CapacityLifeNew,486,328,72,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -41
 |42,TargetConstructionInProgressNew,406,280,135,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |43,ConstructionTimeNew,380,472,92,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |44,ConstructionTimeNew,643,305,103,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |45,HistoricalOrdersNew,810,142,55,19,3,0,0,0,0,0,-1--1--1,-1--1--1
 |46,48,625,149,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |47,2,701,145,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |48,ChangeInHistoricalOrdersNew,701,179,44,26,40,0,0,0,0,0,-1--1--1,-1--1--1
 |49,PerceivedOrdersNew,726,46,44,23,3,0,0,0,0,0,-1--1--1,-1--1--1
 |50,TimeToPerceiveOrdersNew,847,64,37,28,8,0,0,0,0,0,-1--1--1,-1--1--1
 |51,DurationOverWhichToCalculateTrendNew,852,213,69,30,8,0,0,0,0,0,-1--1--1,-1--1--1
 1
 |52,FractionalTrendInOrdersNew,952,81,46,23,8,0,0,0,0,0,-1--1--1,-1--1--1
 -53
 -54
 -55
 -56
 >34,23,1,0,0,0,0,-1--1--1,1|(400,143)|

>36,29,1,0,0,0,0,-1--1--1,1|(385,581)|
 >36,19,1,0,0,0,0,-1--1--1,1|(588,325)|
 >43,19,1,0,0,0,0,-1--1--1,1|(326,465)|
 >23,20,1,0,0,0,0,-1--1--1,1|(463,365)|
 >42,24,0,0,0,0,0,-1--1--1,1|(368,297)|
 >23,42,0,0,0,0,0,-1--1--1,1|(381,243)|
 >44,42,1,0,0,0,0,-1--1--1,1|(559,275)|
 >40,42,1,0,0,0,0,-1--1--1,1|(448,297)|
 >39,24,1,0,0,0,0,-1--1--1,1|(210,325)|
 >40,36,0,0,0,0,0,-1--1--1,1|(590,376)|
 >20,36,1,0,0,0,0,-1--1--1,1|(629,463)|
 >37,34,1,0,0,0,0,-1--1--1,1|(553,17)|
 >50,37,0,0,0,0,0,-1--1--1,1|(876,36)|
 >49,37,0,0,0,0,0,-1--1--1,1|(792,34)|
 >38,37,0,0,0,0,0,-1--1--1,1|(881,-11)|
 >52,37,0,0,0,0,0,-1--1--1,1|(925,48)|
 >35,20,100,0,0,22,0,-1--1--1,1|(658,410)|
 >35,22,4,0,0,22,0,-1--1--1,1|(778,410)|
 >25,23,1,0,0,0,0,-1--1--1,1|(452,211)|
 >19,31,2,0,0,0,0,-1--1--1,1|(359,378)|
 >43,31,1,0,0,0,0,-1--1--1,1|(433,460)|
 >24,29,1,0,0,0,0,-1--1--1,1|(140,340)|
 >19,24,2,0,0,0,0,-1--1--1,1|(312,357)|
 >32,29,2,0,0,0,0,-1--1--1,1|(175,449)|
 >20,24,2,0,0,0,0,-1--1--1,1|(370,352)|
 >23,24,2,0,0,0,0,-1--1--1,1|(318,281)|
 >30,19,100,0,0,22,0,-1--1--1,1|(390,410)|
 >30,20,4,0,0,22,0,-1--1--1,1|(493,410)|
 >28,21,100,0,0,22,0,-1--1--1,1|(91,415)|
 >28,19,4,0,0,22,0,-1--1--1,1|(184,415)|
 >27,25,2,0,0,0,0,-1--1--1,1|(630,263)|
 >26,25,2,0,0,0,0,-1--1--1,1|(584,215)|
 >47,45,4,0,0,22,0,-1--1--1,1|(731,145)|
 >47,46,68,0,0,22,0,-1--1--1,1|(664,145)|
 >50,49,0,0,0,0,0,-1--1--1,1|(796,56)|
 >49,47,1,0,0,0,0,-1--1--1,1|(690,78)|
 >45,48,2,0,0,0,0,-1--1--1,1|(787,188)|
 >51,48,1,0,0,0,0,-1--1--1,1|(769,223)|
 >49,52,1,0,0,0,0,-1--1--1,1|(813,100)|
 >45,52,1,0,0,0,0,-1--1--1,1|(906,142)|
 >49,45,0,1,0,0,0,-1--1--1,1|(764,90)|
 >51,52,2,0,0,0,0,-1--1--1,1|(904,196)|
 >0,49,0,0,0,0,0,-1--1--1,1|(662,85)|
 >1,26,1,0,0,0,0,-1--1--1,1|(827,338)|
 >8,23,1,0,0,0,0,-1--1--1,1|(325,199)|

>9,8,1,0,0,0,0,-1--1--1,1|(227,138)|
 >10,8,2,0,0,0,0,-1--1--1,1|(301,110)|
 >11,10,1,0,0,0,0,-1--1--1,1|(301,50)|
 >2,23,1,0,0,0,0,-1--1--1,1|(424,173)|
 >6,49,1,0,0,0,0,-1--1--1,1|(653,52)|
 \\---// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *ProductionNew
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,InitialCumulativeProductionNew,610,182,133,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |1,CumulativeProductionNew,533,70,54,23,3,0,0,0,0,0,-1--1--1,-1--1--1
 |2,48,362,72,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |3,2,434,72,6,8,39,131,0,0,-1,0,1--1--1,-1--1--1
 |4,ProductionNew,434,88,64,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |5,DesiredProductionFromMarketShareNew,507,360,167,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |6,CUSignalNew,68,246,59,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |7,NormalCapacityUtilizationRateNew,194,297,146,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |8,CustomerOrdersNew,366,484,97,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |9,CapacityUtilizationRateNew,245,334,116,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |10,PercentageAdjustmentFromCapacityUtilizationNew f,614,294,212,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -11
 |12,DesiredProductionFromCUNew,326,167,130,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |13,RelativeCapacityUtilizationRateNew,311,250,149,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |14,PercentageAdjustmentFromCapacityUtilizationNew,336,215,206,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -15
 |16,ForecastHorizonForProductionNew,533,562,144,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |17,ExtrapolatedProductionNew,401,422,115,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |18,TimeToPerceiveOrders,536,470,107,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |19,CapacityNew,535,157,67,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |20,CapacityNew,164,370,67,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |21,FractionalTrendInOrdersNew,229,546,131,12,0,1,0,1,-1,0,128-128-128,128-128-128
 -22
 >12,4,1,0,0,0,0,-1--1--1,1|(353,116)|
 >17,5,0,0,0,0,0,-1--1--1,1|(447,394)|
 >18,17,1,0,0,0,0,-1--1--1,1|(479,440)|
 >16,17,1,0,0,0,0,-1--1--1,1|(479,485)|
 >14,12,0,0,0,0,0,-1--1--1,1|(332,197)|
 >10,14,1,0,0,0,0,-1--1--1,1|(554,212)|
 >13,14,0,0,0,0,0,-1--1--1,1|(318,238)|
 >9,13,1,0,0,0,0,-1--1--1,1|(284,298)|
 >7,13,1,0,0,0,0,-1--1--1,1|(227,273)|
 >5,9,2,0,0,0,0,-1--1--1,1|(340,326)|
 >0,1,2,0,0,0,0,-1--1--1,1|(595,119)|

>3,2,100,0,0,22,0,-1--1--1,1|(399,72)|
 >3,1,4,0,0,22,0,-1--1--1,1|(459,72)|
 >19,4,1,0,0,0,0,-1--1--1,1|(505,103)|
 >20,9,0,0,0,0,0,-1--1--1,1|(198,354)|
 >20,12,1,0,0,0,0,-1--1--1,1|(101,245)|
 >21,17,2,0,0,0,0,-1--1--1,1|(343,422)|
 >14,6,1,0,0,0,0,-1--1--1,1|(147,185)|
 >13,6,1,0,0,0,0,-1--1--1,1|(121,275)|
 >5,12,2,0,0,0,0,-1--1--1,1|(488,265)|
 >8,17,0,0,0,0,0,-1--1--1,1|(379,459)|

\\---// Sketch information - do not modify anything except names

V160 Do not put anything below this section - it will be ignored

*SalesNew

\$Times New Roman|12||0-0-0|0-0-0|0-0-0

|0,BacklogNew,278,323,40,20,3,0,0,0,0,-1--1--1,-1--1--1
 |1,48,68,324,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |2,48,479,320,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |3,HighEndDemand,122,164,80,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |4,2,168,318,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |5,CustomerOrdersNew,168,338,86,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |6,2,402,320,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |7,FulfillingOrdersNew,402,336,86,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |8,InventoryNew,295,429,40,20,3,0,0,0,0,-1--1--1,-1--1--1
 |9,48,67,429,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |10,TechnologyIndicator,31,182,95,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |11,48,524,430,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |12,2,416,429,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |13,ShipmentsNew,416,445,62,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |14,2,159,427,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |15,ProducingNew,159,447,61,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |16,DesiredShippingNew,641,365,88,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |17,DesiredShippingTimeNew,539,222,108,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |18,MaximumShippingNew,228,494,95,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |19,FastestShippingTimeNew,116,589,104,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |20,MaxRelativeToDesiredShippingNew,364,573,150,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |21,EffectOfMaximumShippingOnShippingNew,448,517,175,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |22,HighEndOrdersNew,121,213,83,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -23
 |24,PCDemandNew,330,161,77,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |25,MarketPriceIndexNew,291,96,92,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |26,InitialInventoryNew,328,473,82,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |27,FirmPriceIndexNew,188,99,83,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |28,EffectOfMaximumShippingOnShippingNew f,618,472,181,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|29,PercentageOfOrdersNew,235,139,106,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|30,PCOrdersNew,215,231,61,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
-31
|32,LowEndOrdersNew,309,219,82,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|33,DeliveryDelayNew,293,372,80,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|34,ProductionNew,93,511,75,12,0,1,0,1,-1,0,128-128-128,128-128-128
|35,PriceNew,273,60,53,12,0,1,0,1,-1,0,128-128-128,128-128-128
-36
-37
|38,LowEndDemandNew,466,189,98,12,0,1,0,1,-1,0,128-128-128,128-128-128
>29,22,0,0,0,0,0,-1--1--1,1|(183,172)|
>29,32,0,0,0,0,0,-1--1--1,1|(266,173)|
>13,33,1,0,0,0,0,-1--1--1,1|(321,401)|
>0,33,0,0,0,0,0,-1--1--1,1|(284,344)|
>32,4,0,0,0,0,0,-1--1--1,1|(238,268)|
>30,4,0,0,0,0,0,-1--1--1,1|(193,270)|
>29,30,0,0,0,0,0,-1--1--1,1|(226,178)|
>25,29,0,0,0,0,0,-1--1--1,1|(268,113)|
>27,29,0,0,0,0,0,-1--1--1,1|(205,114)|
>22,5,2,0,0,0,0,-1--1--1,1|(181,331)|
>28,21,0,0,0,0,0,-1--1--1,1|(539,492)|
>16,20,1,0,0,0,0,-1--1--1,1|(572,569)|
>19,18,0,0,0,0,0,-1--1--1,1|(166,546)|
>26,8,0,0,0,0,0,-1--1--1,1|(318,460)|
>21,13,2,0,0,0,0,-1--1--1,1|(404,469)|
>20,21,2,0,0,0,0,-1--1--1,1|(382,516)|
>18,20,1,0,0,0,0,-1--1--1,1|(261,543)|
>8,18,2,0,0,0,0,-1--1--1,1|(233,475)|
>16,12,2,0,0,0,0,-1--1--1,1|(500,372)|
>17,16,2,0,0,0,0,-1--1--1,1|(592,265)|
>0,16,2,0,0,0,0,-1--1--1,1|(426,258)|
>13,7,2,0,0,0,0,-1--1--1,1|(391,387)|
>14,9,100,0,0,22,0,-1--1--1,1|(114,427)|
>14,8,4,0,0,22,0,-1--1--1,1|(210,427)|
>12,8,100,0,0,22,0,-1--1--1,1|(372,429)|
>12,11,4,0,0,22,0,-1--1--1,1|(469,429)|
>6,0,100,0,0,22,0,-1--1--1,1|(357,320)|
>6,2,4,0,0,22,0,-1--1--1,1|(439,320)|
>4,1,100,0,0,22,0,-1--1--1,1|(119,318)|
>4,0,4,0,0,22,0,-1--1--1,1|(206,318)|
>34,15,0,0,0,0,0,-1--1--1,1|(120,483)|
>35,25,0,0,0,0,0,-1--1--1,1|(278,71)|
>35,27,0,0,0,0,0,-1--1--1,1|(236,76)|
>38,32,0,0,0,0,0,-1--1--1,1|(394,202)|
>3,22,0,0,0,0,0,-1--1--1,1|(121,181)|

>10,22,0,0,0,0,0,-1--1--1,1|(68,195)|
 >24,30,2,0,0,0,0,-1--1--1,1|(236,212)|
 \\--// Sketch information - do not modify anything except names
 V160 Do not put anything below this section - it will be ignored
 *DemandNew
 \$Times New Roman|12||0-0-0|0-0-0|0-0-0
 |0,MarketAveragePriceNew,162,664,115,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |1,TotalPCMemoryDensityRequirement,284,349,159,12,0,1,0,1,-1,0,128-128-128,128-
 128-128
 |2,Time,660,354,34,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |3,TechnologyIndicator,193,307,95,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |4,SmoothedPercentage,863,287,49,28,3,0,0,0,0,0,-1--1--1,-1--1--1
 |5,48,550,280,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |6,2,663,281,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |7,ChangeInSmoothedPercentage,663,301,121,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |8,SmoothingTime,575,341,64,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -9
 |10,Time,879,412,34,12,0,1,0,1,-1,0,128-128-128,128-128-128
 |11,HighDemandIndicator,257,276,89,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |12,HighEndDeamandIndicatorDelayed,283,250,142,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -13
 -14
 -15
 -16
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 -30
 -31
 -32
 -33
 -34
 |35,MainstreamDemandNew,390,187,100,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -36
 |37,PCDemandNew,413,262,66,12,0,0,0,0,-1,0,-1--1--1,-1--1--1

|38,LowEndDemandNew,594,220,87,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
-39
-40
-41
-42
|43,PerceivedIndustryDemandNew,697,139,57,23,3,0,0,0,0,-1--1--1,-1--1--1
|44,48,277,134,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
|45,PCMemoryGrowthRateNew,489,317,114,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|46,TimeToPerceiveDemandNew,414,88,120,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
|47,2,451,134,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|48,ChangeInPerceivedindustryDemandNew,451,150,162,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
1
-49
|50,PCIndustryGrowthRateNew,543,395,113,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
-51
-52
|53,Time,634,712,34,12,0,1,0,1,-1,0,128-128-128,128-128-128
-54
-55
-56
|57,LowEndUnitsNew,810,220,75,12,0,0,0,0,0,-1--1--1,-1--1--1
|58,DemandNext,586,193,53,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
-59
-60
-61
|62,HistoricalPriceNew,502,730,42,28,3,0,0,0,0,-1--1--1,-1--1--1
|63,48,321,716,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
|64,2,392,717,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
|65,ChangeInHistoricalPriceNew,392,752,48,27,40,0,0,0,0,-1--1--1,-1--1--1
|66,PerceivedMarketPriceNew,418,648,49,24,3,0,0,0,0,-1--1--1,-1--1--1
|67,TimeToPerceiveMarketPriceNew,233,609,43,30,8,0,0,0,0,-1--1--1,-1--1--1
|68,DurationToCalculateTrendInPriceNew,527,826,56,23,8,0,0,0,0,-1--1--1,-1--1--1
|69,FractionalTrendInPriceNew,588,630,46,26,8,0,0,0,0,-1--1--1,-1--1--1
-70
-71
-72
-73
-74
-75
|76,PCDemandNew f,705,415,71,12,0,0,1,0,-1,0,-1--1--1,-1--1--1
|77,PercentageBecomingNew,695,324,104,12,0,0,1,0,-1,0,-1--1--1,-1--1--1
|78,PriceNew,723,507,53,12,0,1,0,1,-1,0,128-128-128,128-128-128
|79,MarketAveragePrice,877,511,96,12,0,1,1,1,-1,0,128-128-128,128-128-128
|80,RelativePriceIndex,810,378,78,12,0,0,1,0,-1,0,-1--1--1,-1--1--1
|81,MarketAveragePriceNew,758,455,104,12,0,0,1,0,-1,0,-1--1--1,-1--1--1

|82,HighEndDemand,311,217,69,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |83,HighEndUnits,137,202,57,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -84
 |85,UnitIndex1New,352,548,64,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |86,PriceSensitivenessOfMemoryDemandNew,361,433,171,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 -1
 |87,PricesensitivenessDelayedNew,386,372,127,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |88,DemandSensitiveNew f,178,544,96,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |89,DemandSensitivenessSwitchNew,132,493,135,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |90,PerceivedFractionalPriceTrendNew,759,571,69,28,3,0,0,0,0,-1--1--1,-1--1--1
 |91,48,437,567,8,8,0,132,0,0,-1,0,-1--1--1,-1--1--1
 |92,2,529,564,6,8,39,131,0,0,-1,0,1-1--1--1,-1--1--1
 |93,ChangeInPerceivedPriceTrendNew,529,580,142,12,32,0,0,0,-1,0,-1--1--1,-1--1--1
 |94,DemandNew f,439,479,59,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 |95,TimeToPerceivePriceTrendNew,481,514,132,12,0,0,0,0,-1,0,-1--1--1,-1--1--1
 >86,87,0,0,0,0,0,-1--1--1,1|(370,408)|
 >90,86,1,0,0,0,0,-1--1--1,1|(559,466)|
 >95,93,0,0,0,0,0,-1--1--1,1|(500,541)|
 >90,93,0,0,0,0,0,-1--1--1,1|(687,573)|
 >92,91,68,0,0,22,0,-1--1--1,1|(484,564)|
 >92,90,4,0,0,22,0,-1--1--1,1|(612,564)|
 >89,86,1,0,0,0,0,-1--1--1,1|(210,462)|
 >94,86,0,0,0,0,0,-1--1--1,1|(406,459)|
 >88,86,0,0,0,0,0,-1--1--1,1|(263,492)|
 >85,86,2,0,0,0,0,-1--1--1,1|(394,473)|
 >83,82,2,0,0,0,0,-1--1--1,1|(177,194)|
 >78,81,0,0,0,0,0,-1--1--1,1|(736,486)|
 >81,80,0,1,0,0,0,-1--1--1,1|(779,422)|
 >80,77,0,1,0,0,0,-1--1--1,1|(758,353)|
 >79,80,1,1,0,0,0,-1--1--1,1|(865,439)|
 >76,77,2,1,0,0,0,-1--1--1,1|(706,354)|
 >53,69,1,0,0,0,0,-1--1--1,1|(613,684)|
 >58,35,1,0,0,0,0,-1--1--1,1|(494,193)|
 >50,45,1,0,0,0,0,-1--1--1,1|(529,357)|
 >45,37,1,0,0,0,0,-1--1--1,1|(457,284)|
 >57,38,1,0,0,0,0,-1--1--1,1|(673,203)|
 >38,35,2,0,0,0,0,-1--1--1,1|(543,206)|
 >37,35,2,0,0,0,0,-1--1--1,1|(429,223)|
 >35,48,2,0,0,0,0,-1--1--1,1|(410,166)|
 >46,47,2,0,0,0,0,-1--1--1,1|(445,100)|
 >43,48,2,0,0,0,0,-1--1--1,1|(529,173)|
 >47,44,100,0,0,22,0,-1--1--1,1|(365,134)|
 >47,43,4,0,0,22,0,-1--1--1,1|(548,134)|
 >64,62,4,0,0,22,0,-1--1--1,1|(429,717)|
 >64,63,68,0,0,22,0,-1--1--1,1|(357,717)|

>67,66,1,0,0,0,0,-1--1--1,1|(273,599)|
>66,64,1,0,0,0,0,-1--1--1,1|(393,672)|
>62,65,2,0,0,0,0,-1--1--1,1|(474,791)|
>68,65,1,0,0,0,0,-1--1--1,1|(415,814)|
>66,69,1,0,0,0,0,-1--1--1,1|(527,632)|
>62,69,1,0,0,0,0,-1--1--1,1|(541,696)|
>66,62,0,1,0,0,0,-1--1--1,1|(452,682)|
>68,69,2,0,0,0,0,-1--1--1,1|(570,762)|
>0,66,0,0,0,0,0,-1--1--1,1|(316,654)|
>1,37,1,0,0,0,0,-1--1--1,1|(318,293)|
>6,4,4,0,0,22,0,-1--1--1,1|(741,281)|
>6,5,100,0,0,22,0,-1--1--1,1|(607,281)|
>8,7,0,0,0,0,0,-1--1--1,1|(612,323)|
>77,7,0,0,0,0,0,-1--1--1,1|(679,305)|
>4,37,1,0,0,0,0,-1--1--1,1|(649,236)|
>4,7,0,0,0,0,0,-1--1--1,1|(805,290)|
>82,35,0,0,0,0,0,-1--1--1,1|(343,204)|
>3,11,0,0,0,0,0,-1--1--1,1|(219,294)|
>2,77,0,0,0,0,0,-1--1--1,1|(672,343)|
>10,80,0,0,0,0,0,-1--1--1,1|(850,398)|
>87,37,1,0,0,0,0,-1--1--1,1|(389,316)|
>69,93,0,0,0,0,0,-1--1--1,1|(555,602)|
>11,12,0,0,0,0,0,-1--1--1,1|(265,267)|
>12,82,1,0,0,0,0,-1--1--1,1|(335,238)|