SHIFTING GLOBAL LEADERSHIP IN THE WORLD STEEL INDUSTRY

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THESIS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX TABLES

ASTRACT

SHIFTING GLOBAL LEADERSHIP IN THE WORLD STEEL INDUSTRY

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Since the world steel industry began to develop in England, global leadership in the world steel industry shifted from England to the United States and then to Japan in the late 1970s.

The development of steel industry and evolution of international competitiveness are influenced by several factors in the U.S. and Japanese steel industry, which provide an interesting case study for examining the key success factors as well as failure factors. In this regard, the purpose of my thesis is to find out what factors caused the shift of world leadership in the steel industry by analyzing of the case of the U.S. and Japanese steel industry. This thesis explores the major factors that resulted in the decline of the U.S. steel industry and contributed to the rise of the Japanese steel industry including the rise of NSC as the world's largest steel producer.

This case study regarding the U.S. and Japanese steel industry gives several important implications to the Korean steel industry and POSCO. First, continuous cost cutting efforts for maintaining comparative advantage is necessary in today's competitive environment. Second, POSCO has to pay more attention to technology development and engineering capability through intensive R&D in order to overcome the limitation of quantitative growth. Third, POSCO should apply a win-win strategy for mutual growth with steel consuming industries because supportive demand from the automobile and shipbuilding is absolutely necessary.

I. INTRODUCTION

The world steel industry began to develop in England with the start of the Industrial Revolution. However, leadership position in the world steel industry shifted from England to the United States in the early 20th century. The U.S. steel industry maintained constant growth until the 1960s, but experienced a sharp decline from its preeminent role after the oil crisis in the 1970s. On the other hand, the Japanese steel industry, under Japan's high economic growth of the 1960s, surpassed the American steel industry in a relatively short period of time, resulting in Japan becoming the world's leading nation in terms of steel production and its associated technology. Historically, global leadership in the world steel industry moved from England to the United States, and then to Japan in the late 1970s.

An interesting question arises as to which nation and which steel producer will assume global leadership in the future. There are many potential countries that could obtain global leadership in the world steel industry; China has a great deal of potential on the basis of its population; the United States has seen steel demand increase again due to the economic prosperity in the 1990s; Europe may expect synergy effects as the result of market integration.

Today, the world steel industry faces an era of intensive international competition due to rapid structural changes in the world steel industry. Some of the forces at work include overcapacity brought about by the imbalance between supply and demand, reorganization through privatization, globalization and M&A, rapid development of new steel technology, trade friction due to the rise of economic blocs and growth of developing countries, severe competition with steel substitutes, and increase of production costs as stricter environmental regulations are enacted.

The Korean steel industry has developed remarkably since the establishment of Pohang Iron & Steel Company (POSCO) in the early 1970s. With the rapid economic growth and industrialization in the 1970s and 1980s, Korea experienced rapid growth in steel production, consumption and trade. In 1998 Korea became the fifth largest steel producer in the world, and POSCO ranked as the world's largest steel producer in terms of crude steel production, surpassing Nippon Steel Corporation (NSC) of Japan, which had maintained its position as the largest steel producer in the world for several years. The rapid growth of the Korean steel industry reflects the evolving international competitiveness of the Korean steel industry. However, despite the emergence of POSCO as the world's largest steel company, considering the comparatively small size of the domestic market as well as the recent slowing down of economic growth following the financial crisis in 1997, it is expected that POSCO will have some limitations to build and maintain global leadership in the steel industry.

The development of the steel industry and the evolution of international competitiveness[1] are influenced by several factors in the U.S. and Japanese steel industry, which provide an interesting case study for examining the key success factors as well as failure factors. In this regard, the purpose of my thesis is to find out what factors caused the shift of world leadership in the steel industry by analyzing of the case of the U.S. and Japanese steel industry. This thesis explores the major factors that resulted in the decline of the U.S. steel industry and contributed to the rise of the

[1] The concept or measurement of international competitiveness has been debated and can be broadly, defined as corporate, industry and national competitiveness - price, quality and technology competitiveness - export, import, and domestic competitiveness - comparative advantage and absolute advantage according to different purpose or direction of research. In the case of a single industry or industry products, the term can be defined more narrowly, as the ability of a country to compete against other countries in international trade, maintaining or increasing its share of world exports and, by the same token, limiting the extent of import penetration into the domestic market.

Japanese steel industry, including the rise of NSC as the world's largest steel producer. With the implications from these analyses, the Korean steel industry, especially POSCO, could establish a competitive strategy[2] for the future and strive to obtain global leadership in the world steel industry by enhancing its international competitiveness.

This thesis is organized into the following chapters: Chapter II explores the characteristics of structural change in the world steel industry and the current situation of the Korean steel industry. Chapter III examines the main factors that caused the decline of the U.S. steel industry. Chapter IV examines the key success factors of the Japanese steel industry and NSC in particular. Finally Chapter V attempts to draw implications for the future of the Korean steel industry and POSCO to enhance its international competitiveness and establish global leadership.

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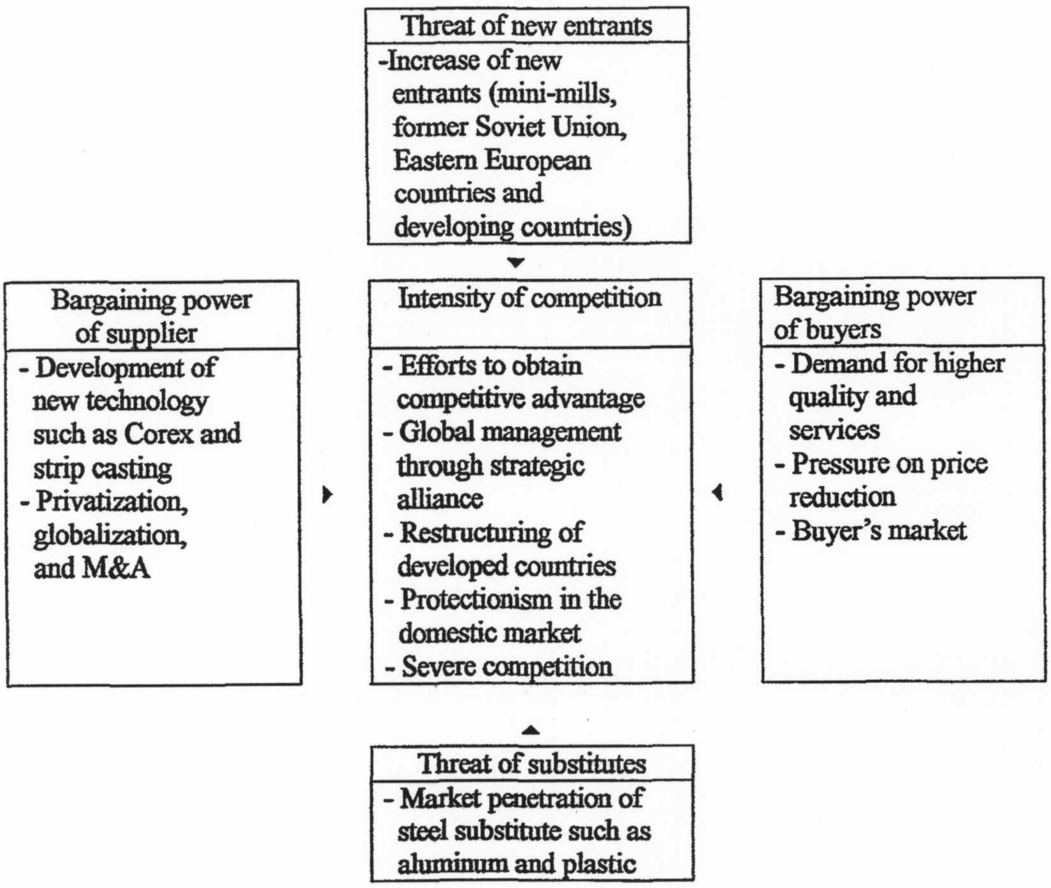
[2] Competition is at the core of the success or failure of firms. Competitive strategy is the search for a favorable competition position in an industry, the fundamental arena in which competition occurs. Competitive strategy aims at to establish a profitable and sustainable position against the forces that determine industry competition. M. E. Porter, *Competitive Advantage*, p 1

II. STRUCTURAL CHANGE OF THE WORLD STEEL INDUSTRY

World Steel Industry Environment

The steel industry traditionally had higher entry barriers than other industries because the industry was regarded as a national prestige industry with high investment to achieve the necessary economies of scale. But, recently the world steel industry has undergone a number of rapid changes resulting in severe competition as shown in Figure 1.

Figure 1 Forces at Work in the World Steel Industry



Structural Change in the World Steel Industry

Changes in World Steel Demand and Supply

The world steel industry had been divided into three segments; the industrialized countries, including the United States, Canada, Japan, and Western Europe; the developing countries, including most of the African and Asian countries, as well as those in Latin America; and up until 1989, the former Communist bloc, consisting of the Soviet Union and several Eastern European countries. Today, these segments no longer exist.[3]

During the period from 1972 to 1996, the world crude steel demand showed an annual average growth rate of 0.7% because of the world recession and changes in the industrial structure of developed countries. While developed countries' steel demand was almost stagnant during this period, demand in the developing countries grew by an annual average rate of 5.5%, so that developing countries' steel demand increased from 8.7% of the world steel demand in 1972 to 26% in 1996. The former Communist countries' steel demand showed a continuous increase until the mid-1980s but decreased since the latter half of 1980s because of political instability (See Table 1).

Table 1 Change in World Steel Demand (million tons, crude steel, percent share)

	1972	1975	1980	1985	1990	1996	Annual Growth Rate
Developed Countries	381.9 (60.5)	335.9 (52.4)	347.5 (48.9)	327.4 (44.9)	374.6 (49.1)	377.6 (50.0)	-0.05
Developing Countries	54.8 (8.7)	76.9 (12.0)	105.8 (14.9)	106.8 (14.7)	129.2 (16.9)	196.2 (26.0)	5.5
Communist Bloc	194.9 (30.9)	227.7 (35.6)	257.4 (36.2)	294.4 (40.4)	259.3 (34.0)	181.8 (24.1)	-0.3
World (Total)	631.6	640.5	710.7	728.6	763	755.6	0.7

Source: IISI, *Steel Statistical Yearbook*

[3] Source: William T. Hogan, *Steel in the 21th Century*, 1994, v

Although world crude steel production constantly increased with active facility expansion of the developing countries such as South Korea and Taiwan, world crude steel production increased by an annual average rate of 1.3% during the entire period from 1970 to 1996. The result is that the world steel production exceeded world steel demand, due to the slow growth in steel production of developing countries and former Soviet Union's significant political and economic change. While steel production and demand in developing countries has increased sharply during the entire period from the 1970s to the 1990s, steel production and demand in developed countries slightly increased during the same period, as shown in Table 2. [4]

Table 2 Change in World Steel Production (million tons, crude steel, percent share)

	1970	1980	1990	1996	Annual Growth Rate
Developed Countries	360.2	406.7	390.3	388.1	0.3
Developing Countries	13.8	55.9	101.6	149.6	9.6
Former Communist Bloc	166.9	251.9	277	214.3	1.0
World (Total)	540.9	714.5	768.9	752.0	1.3

Source: IISI, *Steel Statistical Yearbook*

Change in Steel Trade and Consumption

Steel consumption and trade by region has changed during the past 20 years as shown in Table 3.

Table 3 Change in Steel Production, Consumption and Trade, 1975-1995

(percent share)

Crude Steel Production		Crude Steel Consumption	
Increase	Decrease	Increase	Decrease
- China:3.7→12.4 - Developing Countries: 17.9 →28.3	-Western Europe: 24.1→22.8 -U.S.:16.5→12.4 -Japan:15.9→13.7 -Soviet Union: 22.0→10.5	-Western Europe: 20.8→21.3 -China:4.5→13.6 -Japan:10.6→11.3 -Developing Countries: 24.0→32.6	-U.S.:18.2→15.6 -Soviet Union: 21.9→13.3

[4] Portion of crude steel production in developing countries increased from 2.6% of the world crude steel production in 1970 to 20% in 1996.

Exports		Imports	
Increase	Decrease	Increase	Decrease
- China: 0.4→1.1 - Developing Countries: 5.4 →28.7	-Western Europe: 51.2→45.3 -U.S.: 2.5→1.6 -Japan: 25.3→10.3 -Soviet Union: 15.3→13.3	-U.S.: 9.7→12.6 -Japan: 0.1→2.6 -China: 3.6→11.6	- Western Europe: 38.5→35.7 -Soviet Union: 6.2→2.3 -Developing Countries: 41.9 →35 2

1. Exports and Imports: calculated from 1975-1994
Source: IISI, *Steel Statistical Yearbook*

Steel consumption and trade in the developing countries recorded a high growth rate. But in the case of developed countries such as the U.S., Western Europe and Japan, steel production and exports decreased and steel consumption and imports decreased or only slightly increased. The main characteristic of the structural change in steel production, consumption and exports is the emergence of the developing countries in the world steel stage.

Mega Competition Era

Changing Competition Pattern in the World Steel Industry

Recently the world steel industry is facing new competition under the rapid change of the business environment as shown in Figure 2.

Figure 2 Changing Competition Pattern in the World Steel Industry

	Past	Present
Corporate	-Integrated mill(IM) versus IM -Mini-mill versus Mini-mill	-New competition: Integrated mill versus Mini-mill
Region	-Market dominance of developed countries -Division of world steel market between developed countries and former Communist bloc	-Market share decrease of developed countries -Competition on a global basis among developed countries, developing countries and former Communist bloc
Products	-Immaturity of flat products market -Seller's market	-Consumption increase of flat products -Buyer's market - Severe competition with steel substitutes

The reasons for change in the competition pattern of the world steel industry are as follows:

1. Despite the increase in steel demand, there has been the imbalance of world steel supply and demand resulting from the large scale facility investment on a global basis.
2. The steel industry in developing countries such as China, South America and especially Southeast Asia has rapidly developed and emerged in the world steel market.
3. The steel industry in developed countries such as the U.S., Japan and Germany, which lost their competitiveness during the 1970s and the 1980s, are recovering their international competitiveness through restructuring and rationalization (See Table 4).
4. With the development of new technology, such as thin-slab casting and direct-current electric arc furnace, the mini-mills sector has been able to expand its market range into flat products which were considered as only being within the capability of the integrated mills, in addition to long products which have traditionally been produced by mini-mills.

Table 4 Change in Major Indexes of U.S. and Japanese Steel Industry

		1980(A)		1996(B)		B-A	
	Unit	Japan	U.S.	Japan	U.S.	Japan	U.S.
Production Capacity (Crude Steel)	Million tons	138.6	128.0	110.8	105.3	- 27.8	-22.7
Capacity Utilization	%	79.3	80.4	89.2	91.1	9.9	10.7
Employee	Thousand	375	399	189	138	-186	-261
Labor Hour per ton	MH/T	8.76	10.28	4.24	4.28	-4.52	-6.00

Competition in the world steel industry is undergoing. There are three new types of competition; competition between the developed countries and the developing countries, competition between mini-mills and integrated mills, and competition between steel products and substitute non-steel products.[5] Developing countries, Eastern European countries and the former Soviet Union compete with the developed countries to a significant extent in the world steel market. The developing countries with an especially high growth in steel production and consumption lead the structural change of the world steel market. With the emergence of the mini-mills based on the electric arc furnace in a world steel market which was dominated by the integrated companies, competition increases as the integrated mills' market dominance eroded. As the next decade moves on, more steel will be produced by electric arc furnace as there is an increasing tendency to shift from the blast furnace to electric arc furnace to produce steel.[6] With regard to substitute materials, competition, particularly from aluminum and plastics, becomes greater as the aluminum and plastics manufacturers strive to widen their participation in the automobile and appliance markets.

Change in Trade Structure and Trade Environment

Structural changes in the world steel trade pattern can be summarized as follows:

1. The trade share within an economic bloc has constantly increased because of the spread of the block economy such as NAFTA, APEC and EU, and an increase of self-sufficiency for steel by facility expansion in Southeast Asia, China and the United States.

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[5] Source: William T. Hogan, *Steel in the 21st Century*, 1994, p 4-6

[6] Share of world crude steel production by electric arc furnace has increased from 26.5 % in 1988 to 34.2 % in 1998; *WORLD STEEL STATISTICS* (May, 1999) issued by ISSB. Production increase by mini-mill is due to lower production costs based on lower facility investment costs and higher productivity compared to those of blast furnace.

2. Asia will emerge as the hub of world steel trade through the rapid development of Asian steel industry.
3. The trade share for sheet products, especially coated products has increased because of consumer demand for higher quality as the industrial structure develops.
4. The USSR and Eastern European countries pursued an export-driven policy to secure the funds needed to rationalize their old facilities.

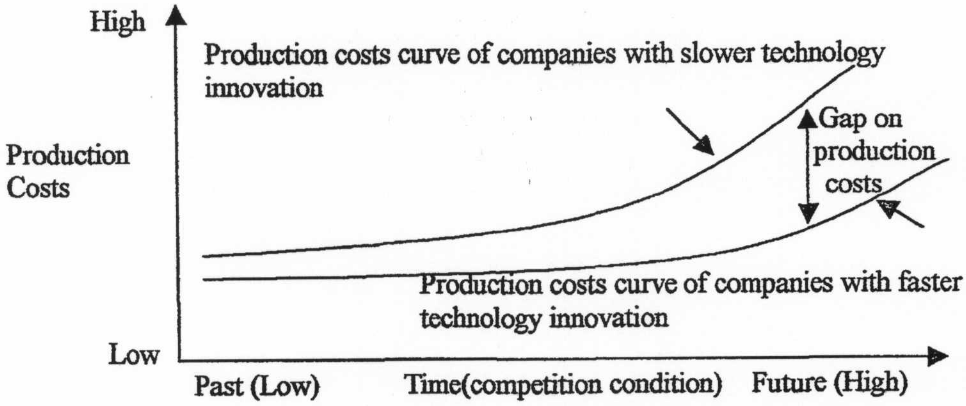
With regard to the world trade environment, free trade system under WTO and protectionism of domestic market coexists. A new trend of steel trade conflicts is that, in recent years, steel trade sues, led by the U.S. in the past, have been frequently done by Southeast Asian countries and South American countries because the former Communist bloc including the USSR increased their steel exports on a low price base. Therefore, the steel trade environment will be more complex and more unpredictable than before because of entry of the East European countries into the world steel market and the emergence of the developing steel producing countries with their production facility expansion.

Rapid Change in Steel Technology

Historically, the importance of technology in the world steel industry was proved by the fact that nations, which developed and adopted new steel technology, built its world leadership in this area. England took its leading position from the 18th century to the end of the 19th century by developing the Bessemer converter. The United States also obtained its global leadership from the early 20th century up to the 1960s by adopting the open hearth, electric arc furnace and large-scale rolling mill. Japan became the global leader in the late 1970s by adopting the large- scale blast furnace, LD converter and continuous casting.

Over a period of fifty-five years since the end of World War II, there have been a number of technological advances affecting virtually every phase of steel production and operations. Most steel-producing companies have taken advantage of the new technologies, many of which have brought radical changes to steelmaking. The structure of the world steel market is being changed to free competition. In order to make a profit, steel producers attempt to reduce their production costs and improve their productivity by developing new steel technologies that increase the speed and efficiency of all production processes. (See Figure 3)

Figure 3 Relation between Competition Condition and Steel Technology Innovation



The speed of technological development is accelerating and the technology life cycle will shorten because steel companies are concentrating their efforts on developing new steel technology on a competitive basis. At present, the development of steel technology is made in the following three areas:

1. With regard to production processes, the major advances in steel technology have been directed at rationalizing process flows to permit an increase in maintaining a continuous operation. These advances enable steel producers to obtain more competitive production processes by speeding production, improving process yields, conserving energy, and

saving facility investments.

2. In the field of steel products, the steel industry has responded to the challenge of substitute materials such as concrete, ceramics, aluminum and especially plastics, in a number of ways, including the development of new products with a low price and high quality. The steel industry has started to listen to the needs of its customers.
3. In the case of environmental protection, environment-friendly steel manufacturing technology for protection of the environment and recycling technology aimed at maximizing the utilization of waste resources as well as natural resources.[7]

In the near future, the world steel industry will face further changes with the development of second-generation new technologies such as smelting reduction process and near net shape casting. With the assistance of their respective government, steel companies in the developed countries such as the United States and Japan are developing smelting reduction processes which can replace at least two process steps of traditional steel production process; sintering and coke making. This will not only result in a saving of investment cost but also help to protect the environment. Near net shape casting, which can produce final products by integration of continuous casting process and rolling process, similar to thin slab casting and strip casting, is being developed because this technology will result in a reduction of production costs as well as saving in facility investment costs.

These new technologies emphasize improvements that increase productivity, reduce costs, and improve quality in every phase of the steelmaking process. Within

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[7] Source: William T. Hogan, *Steel in the 1990s; Growth or Decline*, 1991 p 203

the next ten to twenty years, these new technologies will continue to replace existing steel technology and rapidly change the steel supply structure in the world steel market.

Privatization, Globalization, M&A, and Restructuring

Privatization

In the past, steel industry was regarded as a national prestige industry and governments have operated steel plants at a loss in order to preserve and increase employment. However, recently, the strategic importance of a steel industry has become less because of the end of cold war and the development of an industrial structure. As a result, government-owned steel facilities were privatized in a number of countries in the late 1980s and the 1990s. Since British Steel in the United Kingdom was successfully privatized in 1988, a number of countries including Eastern European countries such as France's Usinor Sacilor, Brazil's CSN, and Philippine's NASCO have followed either by partial or by complete privatization of government-owned facilities. This privatization includes rationalization plans such as closing of old facilities, layoffs of excessive employees, modernization of facilities and management innovation. These privatized steel producers have regained their competitiveness.

Globalization

The steel industry has made rapid progress in globalization due to changing forces at work, such as the development of steel technology, the structural change in the world steel market, the easing of government regulations, the progress of privatization, and the globalization of steel-consuming industries. The strategic motives for globalization in the steel industry are for global outsourcing of raw materials and the enlargement of overseas markets that were connected with the establishment of overseas facilities of the traditional customers of the steel producers.[8] Ispat of India, as the leading global steel company, have production bases in seven countries in the pursuit of global strategy for building overseas production and marketing bases, securing and management of raw materials, efficient procurement and operation of facilities and standardization of operational technology.

Mergers and Acquisitions (M &A)

The advanced steel producing countries including the U.S. have recovered their international competitiveness by restructuring their steel industry. Furthermore, M&A and strategic alliances have taken place in Europe, the U.S. and Japan since the late 1980s. As had already occurred in the banking, telecommunications, and automobile sectors, the steel industry also had its own M&A's, for example, TKS of Germany which was born through M&A between Thyssen and Krupp became the world's third largest steel producer in 1997.[9] Arbed, which ranked the world's seventh largest steel producer in 1997, became the world's third largest steel producer in 1998 through the acquisition of Aceralia and Aristrain of Spain.

M&A and strategic alliances in the steel industry are aimed at establishing a global production and marketing system, rationalization of facilities, reduction of production costs and increase in productivity. These measures have contributed to the enhancement of competitiveness. Therefore, it is expected that the production structure in the world steel industry will be reorganized with fewer steel producers but

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[8] Farth L. Mangum, Sae-Young Kim, and Stephen B. Tallman, *Transnational Marriage in the Steel Industry*, 1996, p 63-75

[9] Thyssen and Krupp ranked respectively world's 8th and 23th largest steel producer in 1990.

on a larger scale. Competition in the world steel market will become greater among large scale steel producers with only the most competitive surviving.

Restructuring

The steel industry in developed countries, which led the world until the mid 1970s, declined following the oil crisis. However, although the U.S., Japanese and German steel industries were confronted with declining demand, considerable excess capacity and significant financial losses, they have pursued radical rationalization programs and made various financial and operation changes through mergers, buyouts, spin-offs, joint ventures, production costs reduction, layoffs, management innovation and development of new technology since the late 1980s. The result has been that a number of steel producers have become competitive and have expanded their production and exports.

Strengthening of Environmental Regulation

International agreements for environmental regulation will be applied to developed countries as well as developing countries. Steel producers and governments are working together in establishing an acceptable environmental policy. The international agreements for environmental regulations have an influence on the steel industry because the steel industry as a large energy consuming industry has environmental pollution problems in both emission and effluent. These environmental regulations will result in an increase of production costs, increase of scrap prices, and will be used as a means for trade restriction in the world steel industry.

Current Situation of the Korean Steel Industry

Korea's rapid industrialization and economic growth in the 1970s and 1980s has resulted in the Korean steel industry's substantial growth over the last three decades. Since the start-up of POSCO in the early 1970s, production volume has expanded rapidly. The growth of the Korean steel industry is associated with not only the remarkable expansion in production and exports but also with the steady increase in domestic demand and imports.

Table 5 Development of Korean Steel Industry (thousands tons, percent share)

			1970	1980	1990	1997
Crude Steel Production	World		595,443	715,605	770,141	798,970
	Korea		504	8,558	23,125	42,554
		Share(%)	0.1	1.2	3.0	5.3
Crude Steel Consumption	World		588,363	722,635	773,640	773,506
	Korea		1,047	6,081	21,478	39,901
		Share(%)	0.2	0.8	2.8	5.2
Exports	World		90,396	140,866	169,261	265,657
	Korea		99	4,524	7,231	11,739
		Share(%)	0.1	3.2	4.3	4.4

Source: IISI, *Steel Statistical Yearbook*

Crude steel production has increased from 0.5 million tons in 1970 to 42.6 million tons in 1997, which amounted to 5.3 percent of total worldwide production. Korea has become the sixth largest producer in the world. Steel consumption reached 39.8 million tons in 1997, which accounted for 5 percent of total world steel consumption. In trade, while steel exports recorded 9.9 million tons in 1996, 4.3 percent of the world steel consumption, steel imports reached 11.1 million tons, 4.9 percent of the world steel imports (See Table 5 and 6). The Korean steel industry's production, consumption[10] and exports is relatively high when compared to the size of the Korean economy.

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[10] In 1997, Korea's apparent steel consumption per capita recorded 829 kilograms. In contrast Japan, Canada and the U.S. respectively 636 kilograms, 502 kilograms and 422 kilograms.

Table 6 Current Position of Korean Steel Industry, 1997 (million tons, percentages)

Rank	Crude Steel Production			Crude Steel Consumption		
	Nation	Production	Share	Nation	Production	Share
1	China	107.3	13.4	USA	123.3	15.9
2	Japan	104.5	13.2	China	120.07	15.5
3	USA	99.2	12.4	Japan	85.70	11.1
4	Russia	46.9	5.9	Germany	41.5	5.4
5	Germany	45.0	5.6	South Korea	39.86	5.2
6	South Korea	42.2	5.3	Italy	28.1	3.6
7	Brazil	26.2	3.3	India	27.28	3.5
8	Ukraine	25.5	3.2	Taiwan	25.24	3.3
9	Italy	25.2	3.1	Russia	18.7	2.4
10	India	23.8	3.0	France	16.54	2.1

Source: IISI(International Iron &Steel Institute): *Largest Steel Producing Countries*, Brussels, 1998.3, IISI, *Short Range Outlook*, Brussels, 1998.3

POSCO has played a role of being the locomotive for the Korean steel industry since it was established in 1968. With its modern, low-cost plant configuration and close proximity to the fastest growing steel region in the world, POSCO achieved the world's largest steel production in 1998 (See Table 7).

Table 7 Steel Production of the Largest Steel Companies (million tons)

Steel Company	Nation	1997		1998	
		Rank	Production	Rank	Production
POSCO	South Korea	2	26.43	1	25.57
NSC	Japan	1	26.93	2	24.07
Arbed Group	Luxembourg	7	12.49	3	20.30
LNM Group	United Kingdom	11	10.90	4	17.20
Usinor	France	5	16.10	5	16.40
British Steel	United Kingdom	4	17.00	6	16.31
TKS	Germany	3	17.50	7	14.80
Riva Group	Italy	6	14.80	8	13.31
NKK	Japan	10	11.12	9	10.54
US Steel	USA	9	11.20	10	10.17

Source: *Metal Bulletin, Top Steel Makers of the 1998*, London

In spite of the Korean steel industry's rapid growth over the past thirty years, there is a possibility that the Korean steel industry would be stuck in the middle between the developed steel producers with their technology advantage and the developing steel producers with their cost advantage. The current external and internal factors that the Korean steel industry faces can be summarized in terms of SWOT analysis (See Figure 4).

Figure 4 SWOT Analysis of the Korean Steel Industry

Strength	Weakness
- Modern facilities and superior operational technology - Abundant well-educated labor force - Abundance of management's entrepreneurship	- Limitation on natural resources such as iron ore and coal, and shortage of scrap - Increase of transportation costs - Erosion of cost competitiveness by labor costs increase - Weakness of engineering capability and products technology
Opportunities	**Threats**
- Adjacency to Southeast Asian steel market which has growth potential - Adjacency to Japanese steel market with high priced products and high level of customer's needs - Steel demand increase after unification between South Korea and North Korea	- Slowdown in growth rate of steel demand due to low economic growth, development of industrial structure and overseas transfer of production base - Change in competition structure by emergence of new technology - Severe export competition by new entrants - Rapid change in trade environment - Costs increase due to strengthening of environment regulation

III. THE RISE AND DECLINE OF THE U.S. STEEL INDUTRY

The Rise and Decline of International Leadership

After the United States steel industry had caught up with British crude steel production capacity, by the 1920s over 50 percent of the world's crude steel was produced in the United States. The U.S. maintained its position as the world's largest steel producing country until the 1970s. The crude steel production capacity of the United States was increased to 165 million tons in 1977 from 100 million tons in 1950. Crude steel production also increased from 31.3 million tons in 1900 to 72.3 million tons in 1945, following the destruction of steel producing facilities in Japan and European countries during the Second World War. The U S. steel industry maintained international leadership in the steel industry as the U.S. economy grew. The U.S reached its peak by producing 137 million tons of crude steel production in 1973.

The main reasons of the American competitive power were the supply of low-cost ores and the introduction of new technology such as the open hearth process and the hot strip mill. Wages were higher and labor productivity was initially lower in America than in Europe. The advanced technology soon overcame a deficiency.[11]

But after the oil crisis in the 1970s, the U.S. steel production decreased sharply. The industry's domestic market share fell to unprecedented levels while the market itself also shrank. In 1984 the U.S. steel industry shipped less steel than any time since 1960 (See Table 8). Steel demand decreased so quickly that the American

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[11] Garth L. Mangum, Sae-Young Kim, and Stephen B. Tallman, *Transnational Marriages in the Steel Industry*, 1996, p 31

steel companies started to lose money in the early 1980s.[12] Crude steel production in the United States plummeted to 67.7 million tons in 1982 from 137 million tons in 1973, as the U.S. steel companies lost their competitive edge both in terms of price and technology.

Table 8 U.S. Crude Steel Production and Net Export (millions of tons, %)

	1900	1920	1950	1960	1970	1984
Crude Steel Production	14.6	49.2	96.8	99.3	131.5	91.5
Percent Share in World's Steel Production	34.2	59.8	48.4	27.6	21.6	11.3
Net Export	0.9	2.2	1.6	-0.2	-6.3	-22.9

a. Net export = Export - Import
Source: Japanese Trade Association, *Change and Prospect of Trade Pattern in U.S.*

There had been a lack of investment and technological advancement since the mid 1970s. The American steel industry began to decline sharply and was finally surpassed by Japan in terms of crude steel production in 1980.

Main Causes of the U.S. Steel Industry's Decline

As the structure of the economy gradually shifts due to changing patterns of consumption and technical progress, basic industries like steel decline, and communications and data processing industries enjoy spectacular growth. The United States is transforming itself into a service economy. In the case of steel, this shift began as far back as the 1950s, when the growth in steel consumption slowed, and was clearly underway by the mid 1970s.[13] Although there are several reasons why the

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[12] The American steel companies, including non-steel operations, lost about $ 3.3 billion – 17 percent of stockholders' equity at the end of 1981 and recorded a loss for 5 consecutive years from 1982 to 1986.

[13] Donald F. Barnett and Louis Schosch, *Steel: Upheaval in a Basis Industry,* 1983, p 5

U.S steel industry, which led the world until the 1960s, has declined sharply since the late 1970s, four are predominant; the decrease of steel demand, low productivity by outdated facilities, high wages and low profits, and side effects of excessive business diversification.

Decrease of Steel Demand

The American steel consuming industries lost their international competitiveness after the 1973 oil crisis. Furthermore, steel demand substantially decreased with the reduction in the size as well as the weight of cars and electric appliances produced by steel consuming industries with the sharp increase of oil price.

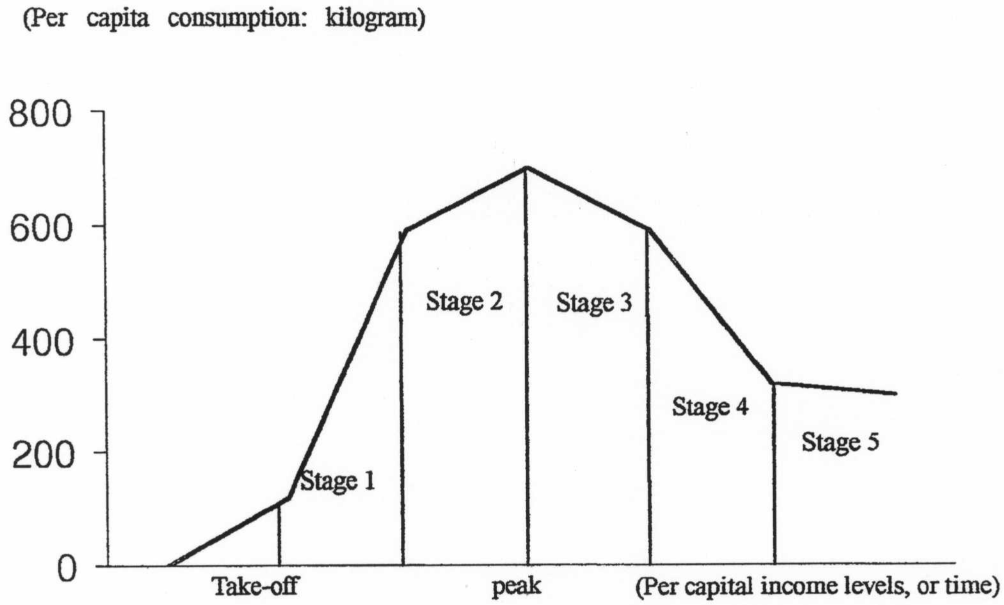
Table 9 Change in U.S. Automobile Production and Steel Shipments to Automobile

	Unit	1973	1982	1990
Automobile Production	Millions of Cars	12.7	7.0	9.8
Steel Shipments to Automobile	Million Net Ton	23.2	9.3	11.1
Steel Shipments per Car	Net Ton	1.83	1.33	1.13

Source: W. Hogan, *Capital Investment in Steel*, 1992

For example, one of the principle steel consumers in the U.S. is the automobile industry. U.S. automobile production decreased to 12.7 million cars in 1973 to 7 million cars in 1982, and the U.S. steel industry's steel shipments for automobiles decreased from 23.2 million tons in 1973 to 9.3 million tons in 1982, because auto mobile demand decreased by the 1981-82 recession and the U.S. consumers preferred smaller cars due to the increase of oil price as well as the enactment of Corporate Average Fuel Economy's Law in 1975 (See Table 9). Since the 1970s, U.S. steel consumption decreased sharply while domestic steel demand in steel consuming industries was sluggish. In terms of the pattern of steel consumption per capita, a study by the Nomura Research Institute showing more clearly the life-cycle of steel consumption,[14] the U.S. steel industry passed the growth stage and was in the mature stage. (See Figure 5)

Figure 5 Economic Growth and the Life-Cycle of Steel Consumption



UK	1890	1960	1964	1973	1985
USA	1900	1964	1973	1982	1990
Japan	1956	1970	1973	1986	1995
Taiwan	1970	1990-95	1995-2000	2005	2015
Korea	1976	1995	2000	2010	2020
China	1995	-	-	-	-

Source: Nomura Research Institute, *Zaikai Kansoku (Market Survey)*, Nov. 1986

Actually, in an advanced economy like the United States, steel demand does not grow at a very rapid rate. Whereas in the U.S. domestic demand increased by 0.4% in the 1950s and 4.3% in the 1960s, in Japan domestic demand increased

[14] According to NRI (1986), steel consumption per capita in a rapidly industrializing country begins to grow quickly after exceeding about 100 kilograms (Stage 1 in Figure 5). The growth rates fall as consumption reaches around 400 or 600 kilograms per head (Stage 2). After peaking at around 700 kilograms, consumption per capita decreases for about 5 or 10 years (Stage 3 and Stage 4) and then enters "Stage 5" where consumption is maintained at around 300 kilograms as steel consuming sectors in the economy mature. The level of per capita consumption at each stage and the speed of shifting from one stage to the next will differ between different countries due to many factors such as differences in industrial structure, economic growth rates and/or population density. Nevertheless, the patterns of the life-cycle of steel consumption would be similar.

sharply by 17.3% in the 1950s and 13.1% in the 1960s (See Table 10).

Table 10 Growth in Apparent Steel Consumption

(compound annual growth rates, 1950-1980)

Period	U.S.	Japan	U.K.	EEC
1950-60	0.4	17.3	3.3	9.8
1960-69	4.3	13.1	2.5	11.1
1969-81	-0.9	1.3	-3.5	-0.9
1950-81	1.0	9.8	0.3	3.6

Source: Federal Trade Commission, *Staff Report on the U.S. Steel Industry and its International Rivals,* Washington, D.C., U.S. Government Printing Office

Outdated Facilities and Low Productivity

Since the U.S. steel industry adopted new technology such as open hearth, the U.S. steel industry developed rapidly and became the world's largest producer of crude steel. But over time new technology such as Basic Oxygen Furnace (BOF) and continuous casting were developed in the 1950s.

In the 1950s, U.S. steel companies invested only to expand their steel production capacity rather than adopt new technologies. The U.S. companies expanded their traditional open-hearth capacity from 90 million to 116 million tons during the 1950s, bypassing the more efficient BOF, which was invented by the Austrians in 1952. Most of facilities in the U.S. steel industry were out of date and worn-out, so capital expenditure during the 1950s went principally to major expansion projects and the modernization of existing facilities rather than to the adoption of new technology. On the other hand, the Japanese and the European steel companies made investments for expansion of production capacity together with adoption of new technology during the 1960s and the 1970s after the restoration of war-destroyed industries. Only three U.S. steel works, amounting to ten percent of total U.S. steel production capacity, were located on the seashore.[15]

As a result, despite substantial capacity expansion during the 1950s, the productivity advantage and the cost competitiveness of the American steel producers began to erode and finally fell behind that of the Japanese or the Europeans. The decline of the U.S. steel industry resulted from the delay in adopting the latest steel technology such as BOF (LD converter) or continuous casting. At that time, the American steel industry adopted the open hearth process, which was the preferred technology during most of the 1950s, instead of BOF. There are several reasons why the American steel industry preferred the open hearth technology

1. The basic oxygen furnace's commercial adoption was not widespread until the late 1950s, so that the American steel industry continued with the open hearth process, which was a proven technology at that time.
2. BOF requires a high capacity blast furnace. Due to requirement of large amount of hot metal, most American steel producers retained their lower capacity blast furnaces which meant that it was difficult to adopt the basic oxygen process.
3. The open hearth process could utilize steel scraps which was abundant in the United States.
4. The American steel producers were reluctant to adopt BOF in the 1950s, as there was no real reason to replace their open hearth furnaces with BOF. They could get enough profits with the structure of steel prices such as an oligopoly pricing policy. And there were no strong competitors to the U.S. steel industry.
5. The American steel industry did not have opportunities to adopt new steel

[15] The American steel works located in the seashore are Bethlehem Steel's Burns Harbor (4.1 million tons) and Sparrows Points (7.3 million tons), and US Steel's Fairless Work (4 million tons).

technologies[16] because steel investments was nearly completed in the 1950s while the Japanese and the European steel industry could adopt the new technologies during their expansion of the facilities in the 1960s.

BOF gives much shorter curing times and therefore requires much less labor and capital per ton of output. It has gradually replaced the open hearth in the United States since U.S Steel started to adopt BOF in 1964, as shown in Table 11. However, the American steel industry's actual adoption and use of the basic oxygen furnace lagged the Japanese by about 7 years.

Table 11 U.S. Raw Steel Output by Furnace Type

Year	Output			
	Basic Oxygen Furnace	Open Hearth Furnace	Electric Furnace	Total
		Thousands of net tons		
1965	22,879	94,193	13,804	130,876
1970	63,330	48,022	20,162	131,514
1975	71,801	22,161	22,680	116,642
1978	83,484	21,310	32,237	137,031
		Percent of total		
1965	17.5	72.0	10.5	100
1970	48.2	36.5	15.3	100
1975	61.6	19.0	19.4	100
1978	60.9	15.6	23.5	100

Source: Robert W. Crandall, *The U.S. Steel Industry in Recurrent Crisis*, 1981, p 7

Furthermore, the American integrated steel companies were much slower to adopt continuous casting, than the European or the Japanese steel companies, because managers in the steel industry did not fully recognize the advantages of continuous casting, and concluded that continuous casting is not suitable for mass-production. On the other hand, in case of the Japanese steel industry, Sumitomo Metals first adopted continuous casting in 1955. Continuous casting rapidly spread out after Yawata Steel

[16] For example, LD converter or computer controlled technology and continuous casting.

adopted continuous casting in 1965. In 1978, whereas the adoption ratio of continuous casting in the American steel industry was 15%,[17] the adoption ratio of Japanese integrated steel companies was 46.2%.

In summary, one of main reasons for the decline of the U.S. steel industry was the industry's failure to invest in modern, large-scale technology during the 1950s.[18] Failing to adopt the basic oxygen furnace and continuous casting as rapidly as the Europeans or the Japanese in the 1960s, and continuing to use outmoded blast furnaces in the 1970s resulted in the U.S. steel industry losing the opportunities to increase productivity and maintain international competitiveness.

Table 12 Adoption of New Technologies, Various Countries

(percent share and millions of net tons)

	U.S.		Japan		EEC(9)		Canada	
	%	tons	%	tons	%	tons	%	tons
A. BOF								
1960	3.4	3.3	11.9	2.9	1.6	1.8	28.1	1.6
1965	17.4	22.9	55.0	24.9	19.4	24.3	32.3	3.3
1970	48.1	63.3	79.1	81.2	42.9	65.1	31.1	3.8
1975	61.6	71.8	82.5	92.9	63.3	87.2	56.1	8.0
1981	60.6	73.2	75.2	84.1	75.1	103.6	58.6	9.4
B. BOF plus Electric Furnace								
1960	11.8	11.7	32.0	7.1	11.5	12.4	40.4	2.3
1965	27.9	36.7	75.3	34.1	31.5	39.5	45.1	4.6
1970	63.5	83.5	95.9	98.4	57.7	87.6	45.9	5.6
1975	81.0	94.5	98.9	111.3	82.6	113.7	76.4	10.9
1981	88.8	107.3	100.0	111.9	98.6	136.0	86.5	13.9
C. Continuous Casting								
1971	4.8	5.8	11.2	11.0	4.8	6.7	11.5	1.4
1976	10.5	13.5	35.0	41.4	20.1	29.7	12.0	1.7
1981	21.1	25.3	70.7	79.0	45.1	62.3	32.2	5.3

Source: Donald F. Barnett and Louis Schosch, *Steel: Upheaval in a Basic Industry,* 1983, p 55

[17] In 1968 National Steel Corporation and Jones Loughlin Steel Corporation first adopted continuous casting in the United States.

[18] Slywotzky insisted that strategic errors by the U.S. integrated mills included the slow adoption of continuous casting, fighting aluminum in beer and soda too late, not fighting plastics in automotive early enough, and not establishing a mini-mill division. For example, they did not realized that the Value Migration from the integrated steel manufacturer' business design to the aluminum-based business design was accelerating so that they lost the can market. The integrated steel companies' reliance on capacity utilization and tons produced dulled their sensitivity to other. By 1973, Japanese mills, U.S. mini-mills, and aluminum producers had displaced 20 million tons of steel from the integrated mills. *Value Migration*, p 93-110

High Wages and Low Profits

The labor cost plays a key role in determining the competitiveness of steel production due to the labor intensity of steel production. While the U.S. industry had the unique advantages of an inland location, proximity to cheap raw materials, and a growing steel demand, rising labor costs might not have posed much of a problem. But when transportation costs fell, world iron ore and coal prices fell in real terms, and developing countries with very low wage rates began to build major steel industries, the level of the U.S. wages began to matter very much.

The U.S. steel industry followed an oligopoly pricing policy, and management had a lenient philosophy on wages since wage increases could be passed on with an increase in steel price. As long as wage increases could be offset by steel price increases, wage increases were not burdensome to steel producers. In addition the steel industry was willing to accede to large wage demands from the steelworkers in exchange for labor peace. Immediately after World War II, the steel industry began a process of wage negotiations and price increases. Each year, after settling the wage increases, the steel producers would announce a major price increase that exceeded the increase in unit labor costs. As Appendix Table 1 shows, labor costs in the steel industry rose very rapidly in the early 1950s. Between 1947 and 1957 the steel industry settled for increase in hourly compensation that averaged 6.6 percent a year while raising prices by 7 percent annually. In the same period, the average hourly wage in manufacturing rose by only 5.2 percent. In 1955, wage paid in the steel industry was about 30 percent above the average wage for all manufacturing industries.

In 1973, when the total compensation for steelworkers reached about 50 percent above the average for all manufacturing industries, the steel industry settled an Experimental Negotiating Agreement (ENA) with the United Steelworkers of America. This agreement guaranteed the workers an automatic 3 percent annual wage increase in terms of annual productivity increase of the entire economy and cost of living allowance (COLA), in return for an agreement not to strike. By 1982, total compensation in steel industry had risen to approximately double the average for all manufacturing. This increase in compensation was not offset by increase in labor productivity. As a result, unit labor costs in the steel industry rose by 220.4 percent between 1972 and 1982, while those in all manufacturing rose by 102.2 percent (See Appendix Table 2). In short, a sharply declining industry was faced with increases in labor costs that were double the manufacturing average over this ten-year period.[19]

Along with wage increases and lack of productivity growth, the main event which happened in the U.S. steel industry was the strike of 1959.[20] The significance is that the steel strike of 1959 resulted in the first rush of imports into the United States. Imports of steel mill products had averaged less than 1.5 million net tons from 1950 through 1958. Suddenly they rose to 4.4 million tons in 1959 (See Appendix Table 3). They were never again to recede to the level of the early 1950s. By 1971, steel imports had reached 18.3 million tons, or 18 percent of U.S. apparent supply.

As a result of the 1959 strike, the U.S. integrated steel mills, for the first time, was faced with serious competition from foreign producers as well as mini-mill producers. U.S. producer prices historically had followed a cost-plus-markup pattern under the oligopoly pricing system. However, the pricing pattern began to change in the 1960s as imports continued to grow.

[19] D. F. Barnett, *Up from the Ashes – the Rise of the Steel Mini-mill in the United States*, 1986, p 41

[20] In 1959, the industry had a very long strike for 116 days – that began in July 1959 and was not finally settled until January 1960 – to attempt to reduce the rate of wage increase in the steel industry.

Table 13 Import Prices to Domestic Prices in the U.S., 1956-82 ($/ NT, percent)

	1956	1960	1965	1972	1982	Annual Growth Rate
U.S. Prices (A)	119.4	130.79	133.26	173.00	281.34	3.6
Imports Prices (B)	172.20	149.93	122.24	161.17	248.88	1.4
Difference(A-B)	-60.26	-18.96	11.02	11.83	32.45	

Average price of Hot-rolled sheets, Cold-rolled sheets, Plates and Bars
Source: Donald F. Barnett and Robert W. Crandall, 1986 *Up from the Ashes – the Rise of the Steel Mini-mill in the United States*

From 1950 through 1957, the U.S. steel industry earned a slightly higher rate of return on equity than the average manufacturing industry. However, after the structural change in the U.S. steel industry with continuous wage increases and increase in imports following the 1959 strike, profit rates began to plummet in the 1960s. The industry's average return on equity was approximately 25 percent below the manufacturing average during the 1960s and the 1970s.[21] Profit margin also fell from 6-8% in the 1950s to 4-6% in the 1960s and 2-3% in the 1970s. Finally, reduced profitability made it difficult for the U.S. steel industry to attract funds for investment. And this in turn made it impossible to maintain the industry's technical leadership and cost competitiveness. [22]

Excessive Business Diversification

In the 1960s, while foreign competitors took decisive measures to adopt new steel technology and modernize their production facilities, U.S. steel companies focused on non-steel related business. As a result, the U.S. steel companies' competitiveness weakened compared to that of foreign competitors.

For example, U.S. Steel (USS) diversified into non-steel related businesses after the late 1960s. Since USS, founded in 1901, diversified into steel related business

[21] R. Crandall, *The U.S. Steel Industry in Recurrent Crisis,* 1981, p 28

[22] Donald F. Barnett and Louis Schosch, *Steel: Upheaval in a Basic Industry,* 1983, p 32

such as distribution and fabrication of steel in the 1950s, USS engaged in non-steel related business such as chemicals, cement and real estate in the 1960s and continued to expand its chemicals business in the 1970s. Furthermore, U.S. Steel entered the oil business by acquiring Marathon Oil Company in 1982,[23] who was a large integrated oil company involved in exploration, production, refining and distribution of petroleum products. At that time, other U.S. steel companies also diversified into non-steel related businesses such as real estate, finance and aerospace business. As a result of business diversification, U.S. Steel consisted of the following divisions in 1982: [24]

1. Steel, including not only steel products but domestic ore and coal operations
2. Oil and gas, including Marathon and its subsidiaries.
3. Chemicals, including the production and marketing of coal chemicals, petrochemicals, plastic resins, and agricultural chemicals.
4. Resource development, including commercial development of mineral and energy resources in excess of U.S. Steel requirements, as well as exploration of new mineral and energy resources.
5. Manufacturing and others, including steel service centers, real estate development, and the manufacturing of products for residential construction.
6. Domestic transportation and utility subsidiaries, including a commercial carrier railroads, domestic barge lines, gas utilities, and a dock company.

However, during 1982 to 1984, U.S. Steel decided to divest itself of a number of business in order to concentrate its efforts in fewer businesses. Despite these divestitures, USS was a highly diversified company in 1984. The following businesses were sold:

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[23] The price was U$ 5.9 billion, of which U$3 billion were borrowed and U$2.9 billion worth of notes were issued.

1. Universal Atlas Cement Division.

2. A considerable amount of real estate, including sixty-two-story office building in Pittsburgh that houses the USS corporate office.

3. A 50 percent interest in Navios, an ocean-shipping line.

4. USS Products Division, with its five plants engaged in manufacturing pails and drums.

5. Extensive coal reserves above the needs of USS.

6. Alside, a manufacturer of housing materials.

7. The electric cable division.

8. The tire-cord division

The U.S. steel industry pursued diversification for the purpose of improving the profit position of the steel business and protecting it against the downside cyclical fluctuations in the steel industry. But steel companies could not concentrate their efforts in their core steel business, and excessive business diversification was detrimental to the growth and competitiveness of the steel industry.

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[24] William T. Hogan, *Steel in the United States: Restructuring to Compete*, p 14

IV. ACHIEVING GLOBAL LEADERSHIP BY THE JAPANESE STEEL INDUSTRY

Global Leadership of Japanese Steel Industry

After the end of World War II, the foundation of the Japanese steel industry had almost collapsed. In February 1949, the US government dispatched Joseph M. Dodge as a superintendent for supervising the economic recovery of Japan. His revolutionary plan, which was called "Dodge Line"[25], considerably affected not only the Japanese industry but also the central government. The Japanese government prohibited subsidies and loans to industry and implemented a fixed foreign currency rate system in order that each industrial sector could secure its own competitiveness. As for the steel industry, the subsidy to the steel industry was provided at around 70% in pig iron producer price and around 50% in finished steel producer price. The steel industry was sustained by other subsidies like domestic coal price which was supplied under special discounted price for designated industry, and imported raw materials price and exported steel reference products price which were governed by the plural exchange rate between ¥100 and ¥600 enabling low rate for import and high rate for export. From April 1949, the steel industry which had been a beneficiary of government's favorable foreign currency system had to adopt a single exchange rate system and adhere to JPY 360/$ rate.

By adopting the "Dodge Line", the Japanese steel industry faced a critical moment. Many doubted the necessity for a Japanese steel industry because of the loss of its international competitiveness and high cost burdens. Paul M. O'Leary, a member of Dodge Mission alleged that the steel and the aluminum industries were not necessary. To defend its existence, the Japanese steel industry strove to rationalize its facilities with the help of a technological mission sent by the U.S.

[25] Dodge announced his economic reforms in what came to be called " the Dodge Line". The Dodge Line had four basic goals: to achieve a true balance in the consolidated budget, to abolish government subsidies, to terminate loans from the Reconstruction Finance Bank and to establish a single exchange rate.

government to modernize the obsolete technologies. At that time, the price of the Japanese steel product was the highest in the world.[26] The Japanese steel industry was near to collapse when the Japanese government prohibited subsidies in July 1950. All these subsidies began to be removed gradually. This action had the effect of raising the total cost and steel products tag price. Thus the steel industry had to strive to reduce the cost by their own efforts by decreasing raw material consumption.

But in 1950, Japan saw a dramatic turning point that was brought about by the Korean War. The Korean War induced unexpected military demand from the American armed forces in Korea and every circumstance surrounding Japanese industry, including the financial situation, turned to assist in an upward growth. With world economic growth in the 1950s, the Japanese steel industry was revitalized and secured its competitiveness with the supports of America. In the 1950s, Japan's crude steel demand reached a meager 4.22 million tons, but steadily increased to 19.30 million tons in the 1960s. Based on automobile industry's rapid growth, steel demand reached 71.13 million tons in the 1970s which was a 20-fold increase in two decades. Japan's steel production growth caught up with its high demand for steel. For instance, crude steel production in 1946 was only 0.557 million tons and 4.84 million tons in 1950 and 22.14 million tons in 1960 and 99.93 million tons in 1970. For the first time, Japan's crude iron production capacity reached 193 million tons in 1973. The Japanese steel industry continued its capacity expansion plans and increased steel production so that the Japanese steel industry took over the leadership of world steel production by surpassing the American steel industry in the late 1970s (See Figure 6). Japan has been the world number one crude steel

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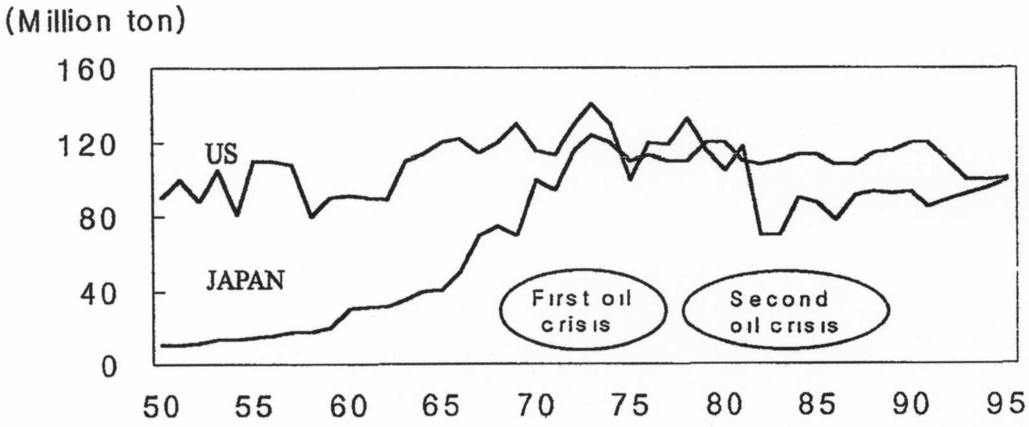
[26] In 1950, Japanese steel sold at $77 per ton while bar steel sold for $73 in Britain, $57 in Germany, $59 in France. Source: Seiichiro Yonekura, *The Japanese Iron and Steel Industry: 1850-1990*, 1994, p 194

producing country since the 1980s until it handed over its number one position to China in 1996. Even though Japan is no longer the number one in terms of crude steel production, it has secured the number one position in terms of technology and product quality.

Figure 6 Change in Crude Steel Production of U.S. and Japan



Main Causes of Japanese Steel Industry's Rise

Rapid Economic Growth and Steel Demand Increase

In the 1940s, the Japanese economy was severely harmed by many factors inherited from World War II. The Japanese steel industry was facing a financial predicament and economic difficulties. At the same time, Japanese steel producers were strongly requested to reform and rationalize their fundamental structure.

However, because of the Korean War in 1950,[27] Japan could escape from this plight and had the opportunity to restart its economic activities with the special demands of Korea and the increased exports. From that moment the Japanese economy could keep ahead with a high growth trend. Japan originally planned a 5% annual growth rate for the year of 1955, which later was changed to 6.5 % by

[27] *Ten Years Steel History of NSC* (1980), P 28

adopting technical innovation and equipment investment in the private sector In 1960, Japanese government prepared a new economic plan to double the GNP in a decade. In 1964 Japan hosted the Tokyo Olympic Games and trade barriers were deregulated, which assisted the Japanese economy to reach nearly full employment. Also consumption was continually increased in the private sector, especially in electric appliances, which enabled sustained economic growth. One of the most important factors in Japan's amazing economic development was the public and private sector's investment in infrastructure and heavy industries. In the financial sector, investment expenditure consumed most of the financial budget. The investment created new demands combined with a low interest rate policy in order to promote an individual company's facility investment. The technical innovations were made mainly in heavy industries such as steel industry, automobile industry, shipbuilding and other electric machinery industries. These industries also invested.

The progress in the heavy and chemical industries resulted in economic growth, providing jobs and increasing GNP with the enhancement of international competitiveness and the expansion of productivity. GATT and IMF played important roles in the development of the Japanese heavy and chemical industries in postwar period. The heavy and chemical industries could be revitalized because these industries could import cheap raw materials and energy from other nations with the removal of international trade barriers. The steel consuming industries such as automobile and shipbuilding industry had grown rapidly. The rapid growth of the steel consuming industries that were internationally competitive brought not only a significant increase in steel demand but also a constant steel demand, thereby ensuring that the Japanese steel industry also grew rapidly (See Table 14).

Table 14 Change in Japanese Automobile Production (millions of units)

	1960	1970	1980	1990
Production	1.0	5.3	11.0	13.5
Steel Shipments to Automobile (ton)	-	4.1	9.5	12.2

Source: Japanese Steel Association, *Steel Statistical Yearbook*

Expansion of Production Capacity by Aggressive Facility Investment

After World War II, Japan's crude steel production capacity rapidly expanded. In 1953, Japan produced crude steel of the highest level and overtook France in 1959, England in 1961 and West Germany in 1964. Japan ranked the 3rd largest crude steel producer in the world after America and Soviet Union.

Such rapid growth in steel production was due to facility modernization and technology innovation through aggressive facility investment. Japan implemented a three stage steel industry rationalization programs from 1951 to 1970 as Table 15 shows. From 1951, the Japanese steel industry launched a rationalization program aimed at facility modernization and technology innovation. The period of the first rationalization was from 1951 to 1955, and the second was 1956 to 1960. The third rationalization program that was called long-term equipment plan started the 10-year term from 1961 to 1970. In that period of time, state-of-the-art steel making plants were built and productivity increased. Also utilization of LD type converter, large blast furnaces and rolling mill process made enormous changes in the iron and steel making process.[28]

Table 15 Rationalization Programs in the Japanese Steel Industry (1955-1970)

Period		Investment (100 m. yen)	Crude Steel Production (t. ton) a	Number of Unit			
				Blast Furnace	Converter	Hot Rolling Mill	Cold Rolling Mill
First	'51~'55	1,282	9,791	33	7	3	7
Second	'56~'60	6,255	23,161	34	13	7	28
Third	'61~'65	10,138	41,296	49	45	13	48
	'66~'70	20,000	86,480	64	83	19	64

a.Crude steel production: final year's production results of each rationalization program

Source: Hirokatsu Ichikawa, *Reorganization of Japanese Steel Industry*, 1968.10, and *Steel Statistics*, various years

[28] Hirokatsu Ichikawa, *Reorganization of Japanese Steel Industry*, 1968, p 113

The First Rationalization Program (1951-1955)

At the end of World Was II, the Japanese steel industry was paralyzed, even though plants and works were not that severely damaged. After World War II, steel demand from the military and raw materials supply from the former colonies disappeared, resulting in a 90% decrease in total production. During the War, the total number of operated blast furnaces reached 35 units. However, operated blast furnaces decreased to 9 units and then decreased to 3 units by the end of 1945. All of them were operated by Yawata Works of Nittetsu.

As its first step, the rehabilitation program for the Japanese steel industry set "Maximization of Coal and Iron Production Plan" decreed by the Japanese cabinet in December 1946. This plan was supported by government actions in areas such as the redemption of price differences and aid from the U.S.A. It took the form of cheap raw materials imports. As a result, Muroran Works of Nittetsu started to operate blast furnace in March 1948, for the first time since World War II. This was followed by the restarting of iron and steel making, and rolling mill operation. These series of actions increased steel production. During this period, facility investment based on the rationalization program focused on the renovation and the rehabilitation of destroyed or aged manufacturing facilities. Technology rationalization was implemented from 1951 following the manufacturing facility rationalization. The first rationalization program was considered as the rehabilitation program by "Dodge Line", aimed at the operational efficiency of outdated facilities.

The first rationalization program had the following characteristics:

1. The rationalization focused on the ordinary steel sector by big steel companies. For a 5 year period, 128.2 billion yen was allocated to ordinary steel production. The big 6 companies' investment occupied 85.2% of the total rationalization investment.
2. The rationalization of the rolling mill process sector, which was considered to be the down stream of steel production. It held 49.1% of

the total ordinary steel related investment. Compared with the iron making (14.1%) and the steel making (10.7%) sectors, the rolling mills sector had a high level of investment ratio. There was a pervasive feeling that even though the modernization of the iron and steel making process were delayed to some extent, the comparative advantage in international and domestic competition could be achieved by the modernization of the rolling mill process, which produced finished steel products with the enhancement in production, productivity and cost management. Among the modernization of the process, strip mill modernization process was the area of concentration. During this period, 7 cold strip mills were constructed. These enhanced not only quality and output but also production capacity, cost, and labor efficiency. At the same time that the modernization was being undertaken, the three open hearth companies, Kawasaki, Sumitomo, and Kobe became integrated steel producers.

3. Facility modernization had been made with foreign advanced technology as Table 16 shows. During World War II, there were developments of new steel-making technology because of the demands imposed by military related goods. The gap between the industrialized nations and Japan was wide. By utilizing the foreign advanced technology, the Japanese steel industry endeavored to close the technology gap. Special tax redemption was applied to equipment and plant rationalization, especially in the rolling mill sector. In addition, the number of technical contracts increased considerably. A class technical contracts (over 1 year) and B class technical contracts (under 1 year) were permitted to be concluded. These technologies were imported first by major blast furnace companies from the U.S. and extended to Europe and then the USSR and communist countries.[29] With the technology monopoly, they

[29] Tsutomu Kawasaki, *Japan's Steel Industry*, p 571

could dominate the domestic market.

Table 16 Steel Technology Imported from Foreign Countries

Raw Materials	Pellet Process(U.S.A), Sinter(West Germany, U.S.A.), Cokes Making(U.S.A.)
Iron Making	Blast Furnace Engineering(U.S.A, West Germany)
Steel Making	Converter(Austria, West Germany), Electric Furnace(U.S.A., West Germany), Continuous Casting(Swiss, the former Soviet Union, West Germany)
Rolling Process	Hot Strip Mill(U.S.A.), Cold Strip Mill(U.S.A, West Germany), Plate Mill Sendzimir Mill(U.S.A.), Annealing Furnace(U.S.A.), Continuous Pickling(U.S.A.)
Coating Process	Tin Coating(U.S.A.), Galvanizing(U.S.A.)
Special Steel	Stainless Steel(U.S.A.)

Source: Hirokatsu Ichikawa, *Reorganization of Japanese Steel Industry*, 1968.10

The Second Rationalization Program (1956-1960)

Based on the outcome of the first rationalization program, the second rationalization program was pursued in order to achieve a comparative advantage in both the overseas and the domestic markets by active facility modernization and technical innovation. The second rationalization plan aimed at the expansion of capacities. The outstanding features of this program were the construction of the integrated steel plant that consisted of modernized facilities, especially the first trial of the combination of BF and LD, in all production processes.[30] Originally the second rationalization program started with a budget of 178 billion yen[31] and 12.67 million tons of crude steel production. However, because of the boom in the world

[30]Japanese steel industry recognized the necessity to develop a long- term supply strategy for raw materials and sent the Scrap Investigation Mission to the U.S, and surveyed the feasibility of procuring raw materials, iron ore in particular, from India, Malaysia, and the Philippines. As a result of survey, they concluded even in the U.S. the supply of scrap was tight and that the international scrap market would be very speculative. Thus Japanese industry strongly perceived the advantage of iron ore as a raw material. The choice of iron ore meant the choice of integrated operations. In the second rationalization program, it was clearly recognized that in order for the Japanese steel industry to survive the unstable scrap market, the shift from non-integrated to integrated production was inevitable.

[31] The financial source for those expansions was foreign capital from the World Bank and others.

steel market and an increase in domestic steel demand, the Japanese steel industry modified the second rationalization program in order to respond to the market situation, which resulted in an expenditure of three times the value of the original budget and doubling of the crude steel production from the original plan (See Table 17).

Table 17 Second Rationalization Program, Plan and Actual Results

(unit: 100 million yen, 1 thousand ton)

	Original Plan (1956.5)	Results
Investment (Ordinary Steel)	1,780	5,486
Crude Steel Production (1960)	12,680	23,161

For the first rationalization program, government special funds by Nippon Development Bank and Long Term Credit Bank were made available to the steel industry which was given priority over other industries such as electric, coal mining and ocean liner business. Moreover, Japan entered a high economic growth era in 1955 under the background of a world economic recovery. These simultaneous events showed the steep increase in Japanese steel demand under a high economic development during the same period so that the Japanese steel industry moved forward to be the number one in the world. The Japanese steel industry expanded its market share through the introduction of new products utilizing new technology and creating new demands to cope with the steel surplus caused by the expansion of production capacity. However, it could not avoid the severe competitive situation as similar products were produced by the steel companies due to the limitation of developing new products with new technology. Each steel producer's mass production and cost cutting efforts caused keen competition. In the period of the second rationalization, the total investment amount reached 625.4 billion yen.

The second rationalization program was different from the first rationalization program.

1. The second program was not initiated by the government, as the first one had been, but by the industry itself.

2. The main emphasis of the second program was put on the construction of blast furnaces. Expansion and construction of an integrated production system were the main goals of the second program. This contrasted greatly with the first program.[32] Steel Works joined forces in the form of taking pair with each steel works such as Tobata-Hirohata[33] and Chiba-Wakayama. The modernization process was the drive to become an integrated steel producer. This was the second group, represented by Kawasaki Steel, Sumitomo Steel and Kobe Steel. Steel works built in that period had modern facilities and efficient raw materials loading system including product delivery system. Especially, the American line-staff system, foreman system, and IE were adopted.

3. The first rationalization program mainly focused on facility rationalization in the rolling process sector. However, in the second rationalization, investment was mainly made in the iron and steel making sector with the construction of large scale blast furnaces[34] and converter lines, etc. As a result, there were 10 blast furnaces, built during the second rationalization period including four 1,500 tons capacity blast furnaces. This was a 10 fold increase from previous rationalization period. At this time, Sumitomo, Kobe and Osaka grew as integrated steel makers. The use of the pure oxygen blowing LD converter was one of main changes in the modernization of rolling process. During the same period, 14 converters were constructed and the size of open hearth was also increased. As a result, Japan had an 11.30 million tons crude steel making capacity in

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32 Seiichiro Yonekura, *The Japanese Iron and Steel Industry, 1850-1990*, 1994, p 216-217

33 These two steel works had been competing and cooperating each other as the center of Wayata Steel and Fuji Steel under the first and second rationalization programs.

34 Most of newly built blast furnace had over 1,000 tons in daily capacity matching the high minimum efficiency scale of the newly introduced basic oxygen furnaces. The adoption of BOF led to the successive adoption of other innovations in the integrated production system and made Japanese steel industry the most efficient and productive in the world.

1955 and 8.20 million tons in 1960.

The Third Rationalization Program (1961-70)

The Japanese government established the double-income plan in 1960. In response to the plan, the steel industry also set a long-term plan that was to achieve 48 million tons of crude steel production by 1970. Thus, the industry prepared for the third rationalization plan. The third rationalization program was implemented by the steel industry itself and not by government as was the first rationalization program. During the third rationalization period, there was an economic recession twice in 1962 and 1965. However, between 1961 and 1965 the investment amount reached 1,014.1 billion yen, 1.6 times that of the second rationalization. Moreover, investment grew rapidly to 2,341.1 billion yen in 1966 to 1970.

The Japanese steel industry accomplished 48 million tons production in 1966, four years earlier than originally targeted. By 1970 crude steel production reached 93.32 million tons, doubling production (See Table 18). By 1964 Japan became the number three steel producing nation followed by West Germany.

Table 18 Third Rationalization Program, Prospect & Actual Results (unit: million ton)

FY	Production		Export	
	Prospect	Results	Prospect	Results
1960	-	23.2	-	3.35
61	26.5	29.4	-	3.33
62	29.5	27.3	-	6.09
63	32.5	34.1	-	7.05
64	35.25	40.5	-	9.97
65	38.0	41.3	3.0	12.95
66	48.0(70)	51.9	5.0(70)	12.51
67	-	63.8	-	12.84

Source: Tsutomu Kawasaki, *Japan's Steel Industry*, p 112

The specific characteristics of the third rationalization program are as follows:

1. Greenfield facilities that had the capacity of 10 million tons of annual

crude steel production were required in order to achieve their production goal. The Japanese steel industry had presumed which 30 blast furnaces would have to be constructed to achieve 48 million tons crude steel production. It was, however, difficult to achieve this goal by expanding the existing facilities so that each steel maker planned to construct new steel works. During this period Sakai Works and Kimitsu Works of Yawata Steel, Oita Works of Fuji Steel, Fukuyama Works of NKK, Mizushima Works of Kawasaki and Kagokawa Works of Kobe were built. The total annual production capacity reached 10 million ~ 12 million tons with 3~4 BF being built by steel makers. These were equipped with large blast furnaces of over 3,000 m3. Along with the construction of large BF, converter, continuous casting and large-scale rolling mill was controlled by a computerized automation system. Through the large blast furnaces, the reduction of fixed expenses per ton and increase in productivity was achieved successively.

2. The location of newly built steel works was matched with a government-planned location program known as "combinat" or "heavy and chemical industry area". The central and local government gave special financial benefits and allowances to the steel producers. Many of them belonged to the "Petroleum, Chemical and Heavy Industry Area" [35] with the formation of the "Pacific Belt Line".

Improvement of International Competitive Capability

The Japanese steel industry could achieve the reduction of cost and improvement of productivity through the three stage steel industry rationalization program from 1951 to 1970. The cost of steel in the beginning of the third

[35] Steel producers sold wasting gas generated in steel works to fertilizer producing companies and petroleum chemistry companies, and purchased oil at a low price from oil producing companies located in petroleum chemistry & heavy industry area.

rationalization program was estimated to reach the same level with that of U.S.A. and West Germany. This was attributed to the reduction of raw material cost 30% compared with the beginning of the first rationalization program and the improvement of productivity in every sector of steel production. As a result, the international competitiveness for export improved remarkably (See Table 19). The use of sinter increased from 46.5% in 1960 to 62.5% in 1965 and the use of limestone decreased from 122 kg to 68 kg. These improvements increased pig iron production and improved the productivity coefficient of blast furnace (See Table 20).

Table 19 Comparison of Raw Material Cost (unit: $)

Year	Iron Making			Finished Steel Making		
	JPN	USA.	UK	JPN	USA	UK
1951	49.0	36.2	28.0	68.2	42.3	23.2
55	44.0	36.3	39.5	53.5	40.5	36.7
60	40.5	38.2	41.0	49.4	40.5	42.5
64	38.0	34.7	34.8	44.4	36.0	38.5

Source: Tsutomu Kawasaki, *Japan's Steel Industry*, p 122

Table 20 Improvement of Iron & Steel Efficiency

	1960	1965	1966
BF Efficiency			
Iron coefficient	1.09	1.42	1.52
Coke ratio (kg)	617	507	504
Sinter usage (%)	46.5	62.5	65.6
Lime usage (kg)	122	68	62
Labor Productivity (hour/ton)			
BF	4.50	2.54	2.20
LD	-	1.34	1.17
OH	5.12	4.11	3.99
EF	11.16	5.64	4.89
Index	100	168	195

Source: Tsutomu Kawasaki, *Japan's Steel Industry*, p 123

Imports of Advanced Technology and its Improvement

The main factors for Japanese steel industry's success were characterized by a series of actions; adopting positive facility investment, importing advanced technologies from other nations and the improvement of imported technologies, so that the Japanese steel industry could lead the world in terms of steel technology. Advanced technology along with new facilities enhanced the competitiveness of the Japanese steel industry and increased steel products exports.

Characteristics of Steel Making Technology in the Postwar Period

During World War II period, a production and technology gap existed between Japan and the other industrialized nations. But the achievement of the rationalization programs with government's protective policies and aid from the U.S. reduced this gap. At the end of the 1960s, the Japanese steel industry reached a high level of technology and equipment. In some aspects, it surpassed the European and the U.S. steel industry with its mammoth scale steel works, which had blast furnaces with a capacity greater than 3,000 m3, world-class level of converters and modernized strip mills, etc.[36]

Even though Japan was proud of its high level of technology in the steel making process, most of these technologies were imported. For example, technologies for pre-treatment of raw materials, sinter, coke making and others came from the U.S. or West Germany. One of the core technologies in steel making, pure oxygen injection converters was imported from Austria or West Germany. More than half of the technology inducement was from the U.S. From 1951 to 1967, the total foreign technology aid reached 416. Competition arose among Japanese steel producers in the adoption of cutting edge technologies from the industrialized nations, giving the Japanese steel industry first class technology in a very short period of time.

Construction of Large- Scale Integrated Steel Works

One of unique characteristics of technology development made in Japanese steel industry after World War II was the construction of large-scale integrated steel

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[36] Source : Hirokatsu Ichikawa, *Reorganization of Japanese Steel Industry*, p 132

works in new locations. From 1945 to mid 1970s, 6 steel companies, Yawata and Fuji built 13 integrated steel works. Production from those works accounted for 60% of Japan's total steel production. The open-hearth users became converter users during the course of the construction of the integrated mills. Converter making iron was superior to open hearth process, due to the efficient use of energy, secured pig iron supplies, cost management by economies of scale, and quality control. Also, second ranking producers, such as Kawasaki built integrated steel works, while frontrunners in the steel industry competed aggressively for market share. At the same time, additional steel works were built as a result of the competition among the monopolistic enterprises.

Most of the Japanese integrated steel works were located in the coastal industrial region, unlike European and American steel works that were mostly located inland. The location of the Japanese steel works in the coastal areas facilitated easy access to carrier liners and allowed fast raw materials unloading. Before World War II, steel works were built near by a coal or an iron mine. Those built after World War II were located in a coastal industrial region for the reasons stated above. With the passage of time, steel works in the coastal region became cost competitive with the stable raw materials price, economies of scale of production facilities, and especially the lower transportation cost by utilizing large-scale carrier liners than the steel producers of the U.S. and Europe.

In addition to the raw material-oriented location, the newly built steel works were located close to customer demand, such as Kawasaki's Chiba Works and Fuji's Nagoya Works. The new steel works were located in a steel consumption area because inland transportation costs were decreased by development of steel consuming industry. The construction of new steel works after the third rationalization program was made in "Local Development Area" or "New Industrial Area" designated by government. With the rapid growth of steel demand, many steel makers could build numerous rolling mill lines that resulted in the growth of works. Before World War II, 2.45 million ton production of Yawata Works had recorded the maximum production capacity in 1941. By the late 1960s, it had reached 8.50 million tons by Sumitomo's Wakayama Works. Most of newly built steel works had targeted a capacity of 10 million ~ 12 million tons.

Active Technology Development in Each Sector

After World War II, blast furnace related technology improvement was mainly focused on the size of the blast furnace, operating conditions, and raw material usage.[37] The maximum capacity of the blast furnace before World War II was 1,000 ton per day, by the end of 1967 it had grown to 21.56 million tons per day with 56 blast furnaces. Fuji's Nagoya 3,000m3 blast furnace, and Kawasaki's Misushima 2,857 m3 No.2 blast furnace, Yawata's Kimitsu 2,700 m3 No.1 blast furnace were built during the third rationalization program. In addition, molten iron productivity, an index of blast furnace's production efficiency was below 1.0 until 1960 and steadily grew to 1.64 in 1967. Molten iron productivity reached above 2.0 with 3,000m3 capacity blast furnaces built in the late 1960s, so the Japanese steel industry obtained world-class blast furnace technology. The adoption of the BF led to the successive adoption of other innovation in the integrated production system and made the Japanese steel industry the most efficient and productive in the world.[38]

Technical improvement in iron making process also progressed with the enlargement of open hearth, oxygen blowing system, top bubbling converter, pre-treatment of pig iron and continuos casting. Especially, the converter treated iron-making process played an important role in the upgrading of the steel making process. From the construction of the first 2 LD converters in Yawata Works in 1957, each of blast furnace makers continuously built the converters. In 1968 the total number of 62 converters outstripped the 58 American steel industry. The converters used in iron making increased to 73.7 % in 1968 from 0.4 % in 1957. There were two main reasons for adopting converter treated iron making.

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[37] Seiichiro Yonekura, *The Japanese Iron and Steel Industry, 1850-1990,* P 104-108
[38] Seiichiro Yonekura, *The Japanese Iron and Steel Industry, 1850-1990,* P 222

1. As a preventive measure for the fluctuation and increasing scrap price, converter does not need much scrap.
2. The high productivity and low construction cost, compared to that of open hearth.

For the casting method, vacuum de-gasser was adopted for the ingot casting method from 1959, it then changed into continuous casting in the 1960s. Continuous casting showed tremendous increase in steel yield and cost efficiency, and the reduction of production hour. Rolling mill technology was also improved with the adoption of computerized auto-control system. The strip mill process was classified as a sample of technology advancement in the steel making process. There was only one hot strip mill of Yawata Works, but by 1968 there were 15. The total production capacity reached 26.91 million tons at the end of 1967 from 0.27 million tons in 1951. The hot strip mill process improved thin plate quality and mass production. In contrast to BF operators which used hot strip mill, the middle and small sized steel companies installed cold strip mill by expanding the capacity to 12.79 million tons with 53 cold strip mills at the end of 1967.

Abundant Labor and Raw Material Transporting System

Along with development of the heavy and chemical industry, Japanese industrial goods gained competitiveness with other industrialized nations through high productivity and advanced technology. The steel industry itself grew rapidly from the 1950s with support from the automobile, shipbuilding, and electric appliance industries. It took an important position in the world steel industry and supplied the Japanese domestic market as well. Japan emerged as the number one steel exporting nation and as the number one coal and iron ore importing nation.

In 1969 Japan imported 99% of its needed iron ore and 89% of its needed coal, which amounted to 43% of the world iron ore imports and 26% of the world coal imports. Iron ore and coal imports from Australia, South America, India and the U.S. increased with rise of steel production. As freight cost rose rapidly, the Japanese steel industry built special carriers that were specially developed as large-sized carriers and incorporated improvements developed by the shipbuilding industry to cut the costs of freight.[39] With reduction of transportation cost by using large-sized carrier, the new Japanese seashore integrated steel plants had more advantage than the American steel producers located in an inland area because of the higher inland transportation costs from the mine to the steel works.

Japanese steel industry maintained its comparative advantage in production cost based on the abundant labor force and low labor cost against industrialized countries including the U.S. (See Table 21). Labor cost of the Japanese steel industry had a comparative advantage to that of the U.S. until the mid 1980s when the Japanese yen appreciated.

Table 21 Labor Costs and Raw Materials Costs

Period	Labor Costs ($/ week)		Raw Materials Costs ($/ton)			
			Iron Ore		Coal	
	U.S.	Japan	U.S.	Japan	U.A.	Japan
1960	122.9	23.7	11.8	14.2	10.6	17.2
1970	179.2	70.4	14.9	11.8	15.0	20.0
1975	273.1	171.3	24.0	16.7	35.8	56.0
1980	448.8	317.3	36.0	27.5	62.0	65.0

Growth of Nippon Steel Corporation (NSC) and Key Success Factors

NSC was established in 1970 through a giant merger of two companies, Yawata Steel and Fuji Steel and emerged as the world's largest steel producer. NSC has exercised influence over the world steel industry by balancing steel supply and demand in the world steel market and exports of steel technology. NSC maintained its position as the world largest steel producer until 1997.

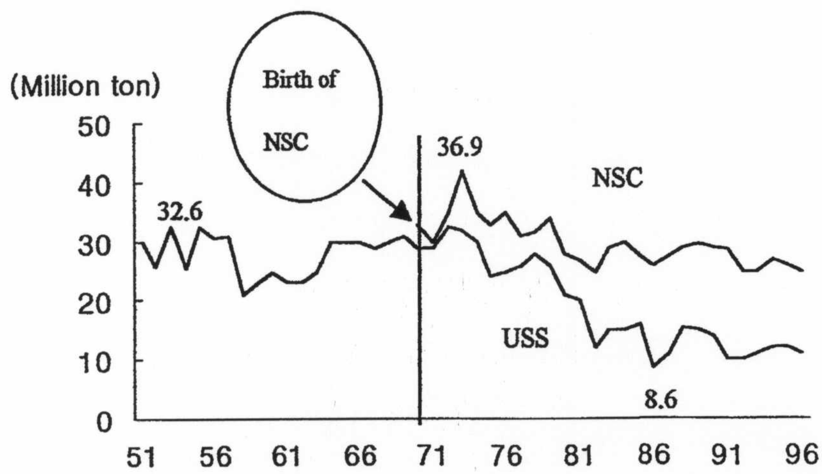
[39]Japan Iron and Steel Federation investigated the full-scaled research about ore carrier system in 1953. The study report disclosed that if it were taken up to use ore carrier the freight cost would be lessened by 15% and that of enlarged size could reduce by another 20%. Tsutomu Kawasaki, *Japan's Steel Industry*, p 446-447

The Birth of NSC

NSC was established in March 31, 1970 through the merger of two companies, Yawata Steel and Fuji Steel. Its original root goes back to Japan Steel. Japan Steel was also created by the merger of government owned Yawata Steel and other small sized private steel works in 1934. Japan Steel produced 97 % of total pig iron and 53% of crude steel. But after World War II, under the dissolution policy of the monopolized enterprise that aimed at the decentralization of excessive economic power, Japan Steel was split up into two purely private companies, Yawata Steel and Fuji Steel. It was then reunified into NSC. While this merger progressed, the Japanese steel industry experienced a rapidly changing business environment since the mid-1960s. England and the U.S. were pursuing a merger and acquisition process and adopting innovative technology such as LD converter, and continuous casting method in order to increase their production capacity. As Japan became a member of OECD and opened its market to international competitors, Japanese steel makers had to face keen competition with advanced and globalized steel companies. Japan announced the merger of two companies, Yawata Steel and Fuji Steel in April, 1968 by the decision of the Fair Trade Commission. NSC was established in 1970.

Key Success Factors of NSC

Figure 7 Crude Steel Production of USS and NSC



With the merger, NSC was born as the top steel producing company in the world. Owing to the steady increase in steel demand under the economic boom from 1965, NSC recorded 32.98 million tons of steel production which was greater than 28.5 million tons production of US Steel.

Economies of Scale through Merger

As the number one steel maker in the world, NSC continued to expand its production capacity to meet the increasing steel demand from automobile industry and other steel consuming industries. The expansion of equipment and plant facilities continued until the end of 1970. The major characteristics of these expansion plans is that the construction of Oita Works and the expansion of Kimitsu Works aimed at being a high-tech steel maker and the most advanced integrated steel plants. Kimitsu Works was the most advanced integrated steel works controlled by an on-line system for the first time in the world. Following the merger, it expanded its production capacity to 10 million tons by construction of No.3 and No.4 blast furnaces to cope with the increase in steel demand. In December 1972, the construction of Oita Works started and was finished in April 1972. For the first time in the world, Oita Works utilized 100% slab casting process and by doing that, it sharply increased its productivity. Kimitsu's expansion and Oita's construction were undertaken with the merits of NSC's merging.[40]

1. Efficient investment led concentrated investment to both Kimitsu Works and Oita Works. The construction of its continuous annealing lines in the cold rolling mill to be made in Kimitsu Works and Nagoya Works was delayed to prevent redundant investment. By postponing the installation of the lines, NSC was able to use the available funds efficiently by investing in both Kimitsu and Oita Works. This was a difficult time to secure financing as the economic recession had begun.

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[40] *Ten Years Steel History of NSC*, 1981, P 353

2. It sharply enhanced the productivity by utilization of exclusive equipment. Oita Works attempted to take advantage from 100% continuous casting integrated steel works construction, because the application of continuous casting line was limited and not utilized generally.
3. A reasonable production allocation among each steel works could maximize the capacity utilization of Kimitsu and Oita Works, during the recession of 1971. Kimitsu Works was at full operation capacity with the cooperation and understanding of the other works and after full operation of Kimitsu in 1972 and 1973. Oita Works was able to operate at full capacity. This consequent operation enhanced productivity overall.

Through a series of production capacity expansion, NSC could produce 51.41 million tons in 1979 from 37.7 million tons in the year of merger. Even though the first oil crisis impacted Japanese steel demand, it recovered in a short period with the growth of the automobile and shipbuilding industries. As a result of the synergy effect through Yawata and Fuji's merger, NSC achieved economies of scale with 44.33 million tons production capacity. NSC enlarged its production capacity to 54.51 million tons by the expansion of Kimitsu Works and the construction of Oita Works until the end of 1970s. The crude steel production increased from 32.98 million tons in 1970 to 40.99 million tons by 1973. NSC could lower production cost by keeping crude steel production around 30 million tons until the late 1970s. Furthermore, with the expansion of capacity that enabled it to become a mega-sized enterprise, NSC was able to control steel consuming industry by market dominance (See Table 22). The birth of NSC changed the competitive market structure to cooperative market structure. NSC's merger was a trial case in the middle of economy recession in the 1970s. In the recession period, to stabilize the steel price, many steel producers agreed to a reduction in the production voluntarily without government interference. At the end of 1971 there was an official production cartel. This cartel negotiated with steel related industries. Finally, steel producers could increase their price several times, even during the recovery period of 1972.

Table 22 NSC's Market Share after the Merger

	Crude Steel	Hot –Rolled Sheet	Cold-Rolled Sheet	Plate	Tin Plate
Market Share(%)	35.5	49.1	41.6	35.6	57.6

Flexible Management Strategy

A key success factor that enabled NSC to maintain its industrial leadership was its pursuit of flexible management strategy in order to cope with the changes in the business environment. The merger initially focused on incresing production capacity and cost competitiveness with economies of scale. But it slowly changed into qualitative management because of the structural change in steel demand following the oil crisis. The export strategy also took the same approach. In the beginning, NSC exported low priced steel products in order to obtain a large volume. But NSC changed its export strategy to qualitative aspect from the 1980s and expanded its exports when domestic market was stagnant.

NSC devoted most of its efforts to secure stable raw materials sourcing as NSC had to rely on foreign purchase of raw materials. NSC invested in coal and iron ore mines in Australia, Brazil, and other countries (See Table 23). NSC made long-term raw materials supply contracts to hedge against the volatility of raw material cost and supply. NSC made both direct and indirect investment by joint ventures in overseas locations to ensure stable raw material supply and securing a safe reserve level.

Table 23 Capital Participation to Overseas' Ore Mines

	Mines	Year	Equity	Participants
Australia	Hamersley	1966	6.2%	6 Steel makers, Mitsubishi
	Mt. Newman	1969	10%	Mitsui, Itochu
	Robe River	1972	4%	NSC, Sumitomo
			31%	Mitsui
	Savage River	1968	50%	Dahlia Co., Mitsubishi
Brazil	MBR	1973	1. 2%	6 Steel makers, 5 Trading Companies
	Nibrasco	1978	49%	6 Steel makers, Nissho Iwai
Chile	Algarrobo	1978	Loan	Mitsubishi
Goa	Chowgule	1979	Loan	5 Steel makers, Okura

Source: Tsutomu Kawasaki, *Japan's Steel Industry*, p 382

But after the first and second oil crisis, the Japanese economy's growth rate fell from the previous high level. The effect of the oil crisis on the Japanese economy was much greater than that of other industrialized nations. From 1973, NSC's total iron production continued to fall. Its increased production capacity resulted in a surplus labor, unused equipment and manufacturing lines. Profits declined caused by the burden of its increased fixed cost such as amortization cost, overhead cost and interest cost. In order to cope with the rapidly changing business environment, NSC announced its first rationalization program in 1978 with the purpose of maintaining not only its international competitiveness but also its global leadership in the world steel industry. The rationalization program included a reduction in production capacity to 36 million tons in 1983 from the previous 47 million tons. NSC adjusted capacity to 28 million tons in the first half of 1980's and 24 million tons in 1985 after the Plaza Agreement. NSC aimed at making a profit while producing less than 24 million tons.

NSC's rationalization program began in 1978, however, an effective plan for rationalization was made from 1984 under the third rationalization program. Between 1978 to 1984, NSC's rationalization programs were implemented. During that period before the Japanese yen appreciated, the managerial target for that program was the realization of an optimal production level by a scale down in production. However, after 1985, the appreciation of the Japanese yen against the US dollar let NSC shift to a new strategy; cost-cutting, restructuring of manufacturing and logistics system and layoff etc. NSC had to set a new vision with a planned diversification. Organizational restructuring and profit oriented department system were also implemented. The organizational structure was changed to a horizontal structure and empowerment of work-site was allowed. NSC's management strategy was focused on rationalization of equipment and production lines, until the middle of the 1980s. In the 1990s, NSC pursued a cost reduction program, personnel rationalization and innovation on task area in order to obtain international competitiveness.

Technology Advantage

After World War II, the Japanese steel producers had imported advanced foreign technologies with technology alliances with industrialized steel producers to minimize the technology gap. For example, in the early 1950s, Yawata and Fuji Steel introduced zinc-coated sheet manufacturing technology utilizing the strip mill method from Armco Steel of U.S.A. The two companies strived to understand and modify the imported technology by themselves. Then they made the imported technology into their own unique know-how. In implementing these aggressive technology development plans in the first year of the merger, NSC provided more technology to others than imported technology from others. NSC had secured a technology advantage in the world steel industry.

For NSC, the most important task in 1970 was technology development. The two companies restructured their R&D centers and exchanged research engineers to enhance technical development. By this cross-functional effort, NSC realized rapid technology improvement. The continuous annealing and pickling line (CAPL), stirring molten iron technology in the continuous casting line, and other new technologies were developed. Operation technology including blast furnace operation technology reached world-class level. Based on these improvements, NSC exported technology and plants to other countries. Human resources management was also centralized to support engineering. In 1972, for the first time in the world, NSC invented CAPL and applied it in the cold rolling mill at Kimitsu Works. On average, it took about 10 days to make cold thin steel sheet from the cold rolled mill to finishing inspection by the conventional cold thin steel sheet manufacturing technology. By CAPL, it could be done in 10 minutes. This was considered an innovative process. CAPL process has reduced labor, energy and construction cost while it improved steel sheet quality for automobiles.

In addition, dynamic control system and direct rolling process for hot coil were developed in 1975 and 1976, followed by technology improvement of 6 stand cold rolling mill process and automatic continuous control systems in 1979. Semisoft coal operation for blast furnace, 50 kg-level high tense plate production was started in 1981. Moreover, NSC utilized a robot operating process for the first time to increase productivity. NSC's technical improvement shifted from productivity and rationalization-oriented process to enhanced steel quality for high value added process. Anti-rust plate for automobile, silver alloy-E and hot BH plate were invented in 1986, and "Thermo Mechanical Control Process Steel" (TMCP) in 1989.

While HR products share in total plate production increased to 47.9 % in 1990 from 59.1% in 1970, CR share increased to 40.9% from 52.1% (See Table 24). NSC chose different product mix in the mid 1980s not only because of operational technology improvement but also because of the appreciation of the Japanese yen. The strong Japanese yen led NSC to shift its marketing strategy for differentiated value-added production, and new steel product development for international competitiveness. NSC's technology and technical development was mainly focused on the work site and line application, and technology was improved by its engineering department. Improved technology played an important role in technology accumulation and increased sales.

Table 24 Change in Product-Mix of NSC

	'70	'80	'85	'90	'95
Hot- Rolled Sheet	59.1%	51.4%	44.8%	47.9%	45.7%
Cold-Rolled Steel	40.9%	48.6%	55.2%	52.1%	54.3%

Continuous Rationalization

For the first 3-years after the merger, huge and large-scale investment in production lines were supported by a high level of economic growth. But chaos in the market system, high inflation and unforeseen market prospect under the first and second oil crisis alerted the Japanese steel makers to prepare for new management strategies. Under these uncertain and unstable market conditions, each steel producer was required to prepare for a survival strategy in the expected long economic recession

NSC made a dramatic change in its investment plan during the lower economic growth phase. No further scale-oriented investment was made after the first oil crisis. NSC reduced its production capacity to 32 million ~ 36 million tons from 47 million tons, aiming at 70% operation. In order to maximize profit with a 70% operation rate, a rationalization program and a new investment strategy were set. A cost minimization plan was implemented by maximizing use of production facilities.

The mid to long-term renovation plan required NSC to prepare for production optimization plan in the economic recession, which required stricter quality control from the customers. Among those detailed action plans, new basic alternatives and newly developed technology adoption led to a cost minimization plan. At that time, rationalization in the hot rolled, cold rolled process and continuous casting operation were progressed under the name of mid to long-term renovation plan. Until 1970, the Japanese steel industry has been pursuing new resource, energy saving technology innovation plan by adopting continuous equipment and production lines. As a result, significant technology improvements and productivity enhancements were made during the economic recession following the first oil crisis. These technology innovations contributed to NSC's world class competitiveness and healthier management

Following the second oil crisis, the decrease in steel demand and the sharp appreciation of the Japanese yen meant that any cost advantage made was lost to other Asian developing countries. Japan downsized its production capacity, from 47 million ton iron making capacity to 30 million tons by consolidating aged equipment and lines combined with a human resource rationalization program. Japanese steel demand decreased to 1970's level between 1985 to 1990. On the other hand, for that period demand for premium steel and coated products was steadily increasing with the raising of living standards and the diversification in the use of steel, so that investment in CGL and GI lines was made. From 1992 when the collapse of

Japanese bubble economy began, NSC shut down inferior production lines and classified its works by production items. For example Muroran Works specialized in wire rod and bars production and Hirota Works did plate production, etc.

V. CONCLUSION AND IMPLICATIONS

The shift of international competitiveness among the nations, especially in the world steel industry, from industrialized countries to newly developed countries is made possible by technology transfer. However, for being a leader in a competitive steel industry, technology innovation and competitive strategy should be developed by the companies themselves. In the case of the Japanese steel industry, Japan caught up the U.S. steel industry by cost competitiveness based on its labor cost advantage and the growth of steel consuming industries such as the automobile and shipbuilding industries. Also, Japan assimilated and improved its steel making technology and operational know-how imported from the U.S.A. It resulted in product quality enhancement and new product development so that the Japanese steel industry secured global leadership.

Like Japanese steel producers, Korean steel producers, including POSCO have taken a similar development route with the rapid demand by the steel consuming industries. But as the Korean economy continues to grow, the importance of steel production and trade to the national economy and its comparative advantage will eventually decline. Korea's relatively low wages, a main source of cost competitiveness, will be eroded gradually.[41] The steel consumption in Korea will experience a slowdown in the near future, a pattern experienced by developed countries. Changes in the structure of steel consumption are also expected. While having in place its steel-intensive infrastructure, Korea will see growth in its capital

[41] Simple factor- based comparative advantage such as labor costs has been shifting over time so that it is rarely sufficient to gain or sustain a strong international position. M. Porter, *Competition in Global Industries,* P 563-564

sector, raising the demand for more advanced or high-quality steel products. The steel industry's relative importance in the Korean economy will decline with respect to steel production and consumption and a slowdown in the growth of steel consumption and domestic demand.

This case study of the U.S. and Japanese steel industry has several implications for the future prospects of the Korean steel industry including POSCO. POSCO, the world's largest steel producing company in 1998, needs to learn the lessons from the American steel industry, and how it lost its industry leadership, and from the Japanese steel industry, how it achieved global leadership by maintaining cost competitiveness and improving technology competitiveness.

First, continuous cost cutting effort for maintaining comparative advantage is necessary in today's competitive market. Despite its short history and lack of experience, POSCO has maintained a cost advantage based on low-cost labor, which was initially an important factor in POSCO's success. However, as labor cost is expected to increase in Korea, POSCO will experience the challenges from other labor affluent nation, like China. To meet these challenges, POSCO should secure comparative advantage by cutting manufacturing and overhead cost. As many allegedly say, cost competitiveness in manufacturing industry is one of the most important factors to survive in the 21st century. Furthermore, maintaining cost competitiveness is necessary for POSCO to survive under the circumstance of vulnerable technology advantage and engineering capability.

Second, POSCO has to pay more attention to technology development and engineering capability to overcome the limitation of quantitative growth. For R&D, POSCO should avoid volume-oriented growth strategy, which played a critical role in securing comparative advantage in the developing stage. Because industries and many companies in Korea are undergoing restructuring under the new IMF order, volume-oriented mass production appears to be no longer appropriate. Fluctuating exchange rate, increasing labor cost, and other unfavorable factors will cause an unavoidable loss in competitiveness. Cost competitiveness will no longer be available to the Korean steel industry because of the expected increase in labor cost. The process of upgrading to achieve and sustain competitiveness against ever-improving international competitors in developed countries as well as emerging lower cost developing countries requires continuous improvements by firms of their capabilities and technologies. Not to lose the comparative advantage, POSCO should concentrate on productivity enhancement, product quality and diversity, and further technological development through R&D, and upgrade its competitive advantage, which will demand true innovation, not imitation of Japanese and other competitor's products and processes. The American steel industry utilized hot strip mill technology that was regarded as an innovative steel making process at that time but could not continue its leadership. Absence of continued equipment and line renovation in production lines caused the collapse of the American steel industry. On the other hand, Japanese steel producers, including NSC strove to modify imported technology and renew it for leadership in the world steel industry.

Third, POSCO should apply a win-win strategy for mutual growth with steel related industries. For steady growth, it should remind itself that supply is always dependent on demand. In this case, favorable demand from the automobile, shipbuilding and electric appliance industry is absolutely necessary. As explained and shown in the previous pages, the secret of the Japanese steel industry's success was based on its supportive demand from steel consuming industries, which is not to be found in the history of American steel industry. Moreover, the Japanese steel industry let the demand side participate in developing products and processes for mutual benefits. From the analysis of the Japanese steel industry's growth, POSCO should utilize the win-win strategy in order to grow with the demand-side participants. Not only direct mutual win-win strategy with supportive industries but also indirect win-win strategy, such as cooperative R&D projects with the steel association and universities is necessary for the Korean steel industry's development and national comparative advantage.

Finally, the current industry structure and the rules of competitive engagement have been defined by the industry leader. Although it may be possible to find a profitable niche in the present industry terrain, there is typically little growth and prosperity to be found in the shadow of the industry leader. The strategy to create tomorrow's industry structure has to focus on being an industry rule-breaker and rule-maker rather than the industry rule-taker. POSCO will need to develop a strategy based on a new core competence and industry foresight which gives a company the potential to get to the future first, stake out a leadership position and informs corporate direction.[42]

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[42] Gary Hamel and C.K.Praharad, *Competing for the Future*, P 29-115

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Appendix Table 1 Price of Steel, Iron Ore, and Steel Labor, 1947-57

Year	BLS price index for steel mill products, including Alloy and stainless (1957-1959 = 100)	Price of iron ore (dollars per net ton)	Total compensation per hour for hourly workers in the steel industry ($)	Unit labor costs ($ per raw ton)	BLS wholesale price index, all commodities (1957-1959 = 100)
1947	45.5	5.55	1.95	29.02	81.2
1948	52.0	6.20	2.14	31.96	87.9
1949	56.4	7.20	2.19	33.35	83.5
1950	59.4	7.70	2.21	32.55	86.8
1951	64.0	8.30	2.47	36.40	96.7
1952	65.4	9.05	2.79	40.65	94.0
1953	70.5	9.90	2.89	40.12	92.7
1954	73.8	9.90	2.95	44.03	92.9
1955	77.2	10.10	3.08	40.25	93.2
1956	83.8	10.85	3.37	44.11	96.2
1957	91.8	11.45	3.76	48.90	99.0
Addendum Annual rate of change (%)	7.0	7.2	6.6	5.2	2 0

Source: R. Crandall, *The U.S. Steel Industry in Recurrent Crisis,* 1981, p 19

Appendix Table 2 Hourly Labor Costs in the U. S. Steel Industry and in All Manufacturing, 1956-78

Year	Hourly Earnings (dollars) a		Total Compensation for All Employees (dollars)	
	Steel industry	Manufacturing	Steel	Manufacturing
1956	2.54	1.95	3.15	2.4
1957	2.73	2.04	3.45	2.54
1958	2.93	2.10	3.79	2.65
1959	3.14	2.19	4.07	2.76
1960	3.09	2.26	4.08	2.87
1961	3.24	2.32	4.27	2.95
1962	3.33	2.39	4.44	3.06
1963	3.39	2.45	4.52	3.16
1964	3.43	2.53	4.61	3.29
1965	3.54	2.61	4.71	3.35
1966	3.64	2.71	4.90	3.50
1967	3.66	2.82	5.06	3.68
1968	3.86	3.01	5.35	3.94
1969	4.12	3.19	5.71	4.20
1970	4.24	3.35	6.05	4.50
1971	4.57	3.57	6.68	4.78
1972	5.22	3.82	7.47	5.03
1973	5.69	4.09	8.10	5.39
1974	6.55	4.42	9.54	5.95
1975	7.23	4.83	11.10	6.66
1976	8.00	5.22	12.22	7.22
1977	8.91	5.68	13.42	7.83
1978	9.98	6.17	14.69	8.47

a. Nonsalaried workers

Source: R. Crandall, *The U.S. Steel Industry in Recurrent Crisis*, 1981, p 36

Appendix Table 3 U.S. Production, Shipments and Imports of Steel Mill Products, 1956-85

Millions of net tons

Year	Raw Steel Production	Total Net Shipment	Imports
1956	115.2	83.3	1.3
1957	112.7	79.9	1.2
1958	85.3	59.9	1.7
1959	93.4	69.4	4.4 a
1960	99 3	71.1	3.4
1961	98.0	66.1	3.2
1962	98.3	70.6	4 1
1963	109.3	75.6	5.5
1964	127.1	84.9	6.4
1965	131.5	92.7	10.4
1966	134.1	90.0	10.8
1967	127.2	83.9	11.5
1968	131.5	91.9	18.0
1969	141.3	93.9	14.0
1970	131.5	90.8	13.4
1971	120.4	87.0	18.3a
1972	133.2	91.8	17.7
1973	150.8	111.4	15.2
1974	145.7	109.5	16.0
1975	116.6	80.0	12.0
1976	128.0	89.4	14.3
1977	125.3	91.1	19.3a
1978	137.0	97.9	21.1
1979	136.3	100.3	17.5
1980	111.8	83.9	15.5
1981	120.8	88.5	19.9
1982	74.6	61.6	16.7
1983	84.6	67.6	17.1
1984	92.5	73.7	26.2
1985	88.3	73.0	24.3
Annual Growth			
Rate (percent)	1.5	0.8	23.6
1956-66	1.7	3.1	4.9
1966-73	-1.7	-1.8	2.5
1973-79	-2.8	-2.9	3.5
1973-81	-7.2	-5.3	5.5
1979-85			

a. Year of expiration of labor contract

Source: Donald F. Barnett and Robert W. Crandall, *Up from the Ashes – The Rise of the Steel Minimill in the United States*, 1986, p 37