Columbia Center
on Sustainable Investment
A JOINT CENTER OF COLUMBIA LAW SCHOOL
AND THE EARTH INSTITUTE, COLUMBIA UNIVERSITY

Jared Talkin [1,2]
March 2016

Key Points

1. Japan established its steel industry based on inputs supplied from territories acquired through its imperialistic pursuits. The loss of these territories post-WWII required the steel industry to completely reconfigure its operations.

2. The government fostered the steel industry early on by implementing tariff protection, controlling over capacity and controlling detrimental competitive price-cutting.

3. The Japanese steel industry was built around the premise of producing high quality, high value products. All irregularities were eliminated, and all inputs and outputs had to meet rigorous specifications.

4. The steel industry has consistently employed the tactic of overcoming market and logistical obstacles through high levels of expenditure on capital improvements and R&D.

Table of Contents

Downstream Beneficiation Case Study: Japan

Introduction

Japan was chosen as a downstream beneficiation case study due to its establishment of its contemporary steel industry in the late 19th century and its emergence as a major international steel producer following World War II. What makes Japan such an interesting case study is that, despite their relative lack of raw materials, Japan developed its steel production capacity to supply its domestic economy and export. Japan became a major steel exporter, and as of 2014 ranked third in the world for crude steel production behind the People's Republic of China (PRC) and the European Union (EU).

In the early 20th century, iron and steel production was a material intensive sector, with raw materials comprising the greater part of costs, especially in countries that relied primarily upon imports such as Japan. Examples of industrialization exhibited in the stories of the birth of the European and US steelmakers (where the industries had matured on the margins of iron ore deposits and coalfields) was very different from the Japanese experience. Prior to Japan, no country had ever ventured into steel making that was comparably resource-poor.[1] For the purpose of this case study, a historical overview of the steel industry is conducted with a focus on factors that have contributed to Japan becoming and maintaining its status as a steel-producing powerhouse.

[1] Jared Talkin is a research fellow at the Columbia Center on Sustainable Investment.

[2] The author would like to thank Perrine Toledano and Nicolas Maennling for their insight and guidance during the course of this project.

Steel Industry 1880-1914

The iron and steel industry was established in the late 1800's as a result of government policy. Between 1880 and World War I most national investment came directly from government coffers.[i] The government concentrated its spending in heavy industries, including militarily strategic sectors and infrastructure, particularly shipping and railroads. Iron and steel were vital inputs for both infrastructure and military hardware.[ii] This reality drove government policy for heavy support of the steel industry. The roots of the contemporary Japanese iron and steel industry can be found in 1854 with the construction of a blast furnace at the Kamaishi Works benefiting from the close proximity to the Oshima iron ore mine (one of the few deposits that Japan had[1]). This project was spearheaded by the government as part of a broad policy practiced during the Meiji era where government enterprises were established in a wide variety of industrial sectors, including pig iron production. The Japanese government was motivated to explore western methods for producing pig iron due to their need to produce armaments more rapidly and efficiently.[iii]

Under the direction of German engineers, the government moved forward with building a commercial pig iron plant in Kamaishi. The facility was established using the latest in production technologies, employing two large blast furnaces, railway components and ancillary equipment that were imported from England, with the plant being commissioned in 1880. The project failed because the plant was too advanced and large-scale and required more established infrastructure than existed at the time, resulting in the Ministry of Industry shuttering the plant in 1882.[iv] The capital assets were sold by the government to Chobei Tanaka, a merchant who established the Kamaishi Mines Tanaka Iron Works in 1887. By 1893 the Tanaka Iron Works was running both of the English blast furnaces and by 1894 the operations produced 13,000 tons of pig iron, equivalent to 65% of Japan's total output of pig iron for that year. Unlike the initial attempts at the Kamaishi Iron Works, the Tanaka Iron Works were successful because they started out with small-scale production facilities and blast furnaces, and only scaled the operations up once they had perfected their production processes.

As a result of the successes realized at the Tanaka Iron Works, the government decided to try its hand again at iron and steel production with the commissioning of the Yawata Steel Works in 1901. Yawata's coastal location was chosen in part because it supported the import of raw materials, most significantly from China, which was known to be a potential source for both coal and iron ore.[2] Despite all of the lessons learned from the failure of the first government foray into pig iron production, the Yawata Works experienced ongoing production problems that were not resolved until the production line had been re-engineered in 1904, with the works eventually becoming profitable in 1910. The bulk of Yawata's output was allocated for civilian purposes, with its principal product, rails, supplying the demand created by the expansion of the state-owned railways. The Yawata Works remained Japan's dominant steel producer up until WWI, accounting for approximately 85% of Japan's steel output.[v]

From its inception, the Yawata Works were geared toward vertical integration as it controlled the Futase coalmines, which provided around 50-60% of its coal consumption. Despite initial plans to supply the Yawata Works with domestically-sourced inputs, the mill relied heavily on imports of iron ore as well as substantial quantities of pig iron and coal from Chinese and Korean territories controlled by the Japanese Empire. [vi]

[1] As of 1920, Japanese reserves of commercially valuable iron ore are less than a year of output of the United States (The Iron and Steel Industry of Japan and Japanese Continental Policies, Abraham Berglund, Journal of Political Economy,Vol. 30, No. 5 (Oct., 1922), pp. 623-654)

[2] Japanese coal, in limited supply, was not of good enough quality to make good coking coal (Berglund, 1922).

Indeed, Japan overcame its deficit in raw materials through a combination of first-mover advantages and imperialistic intervention that ensured that low-cost Asian resources were exclusively available to Japanese producers.[vii] For example, in 1910 Japan annexed Korea, after which Yawata took control of Korea's nationalized iron ore mine. Another instance of this strategy took place in Manchuria, where Japan established the South Manchuria Railroad Company. This semi-public corporation was engaged in the exploitation of raw materials and iron production, with the output being designated for shipment to Japan. Japan's steel industry also benefited from natural protection that translated into high transport costs faced by foreign producers who attempted to export into the Japanese market. In addition, the Japanese steel industry benefitted from the implementation of a 15% tariff on steel imports in 1911. With these tariffs in place Japanese pig iron production was cheaper than that of major steel-producing countries such as the US and Britain. Furthermore, Japan's utilization of marine transport at its coastally-located plants further reduced production costs.[viii]

In 1912, the Nippon Kokan Co. was established though a joint venture (JV) by Hokkaido Coal Mining and Vickers Armstrong, a British manufacturer of armaments and steel. Nippon Kokan Co. and most privately held Japanese steel producers at the time, wanted to avoid the logistical issues and capital costs associated with producing pig iron as an input for steel production. Therefore, they based their steel-making operations on the use of imported scrap from America and pig iron from India. While most private steel makers followed this strategy because of the economic advantage this configuration offered over the short run, steel producers failed to anticipate how their operations would be affected in the event of a shortage of scrap imports or pig iron, or in the event of a rise in the cost of either input.[ix] By 1913, imports still accounted for over half of all pig iron and two-thirds of all steel consumption. Production at the Yawata Works accounted for about 75% of Japan's pig iron and steel output, with half of that output being allocated to the government for use in railroad construction and national defense (with the other half being sold for industrial use).[x]

Steel Industry 1914-1945

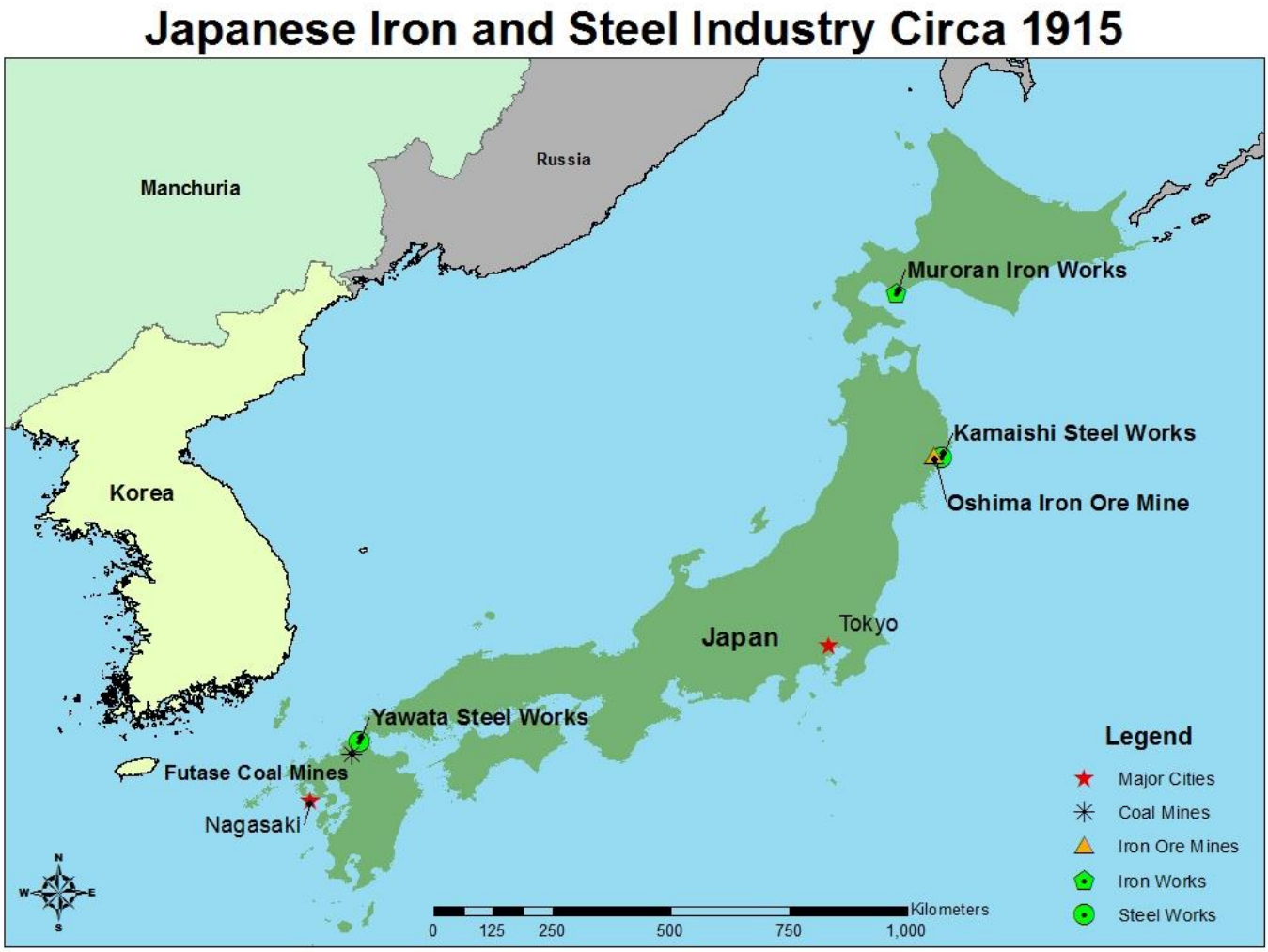
The onset of WWI in 1913 was followed by a boom in the Japanese steel sector, which resulted in a spike in steel prices, and in turn high profits. This boom was assisted by a wartime moratorium on steel imports from both Germany and Britain, thus leading to large-scale investments, technical advances and entry by numerous small-scale private firms, as well as a few large companies. The entrance by new firms allowed for greater product specialization and resulted in industry-wide rationalization. During this period, Yawata increased its steelmaking capacity, to levels comparable with other major international steel producers. At the same time, private firms made extensive capital improvements, which reduced Yawata's overall technological advantage.[xi]

During the 1920s, the Japanese steel industry faced increasing challenges. Domestic producers experienced deflationary pressures arising from several sources, including domestic and worldwide recession and an overvaluation of the yen. Furthermore, high labor costs resulting from an overvalued yen caused the iron and steel industry to lose competitiveness. Because coal mining was labor intensive, high wages had a significant impact on the cost of domestic coal.[xii] While steelmakers who imported their pig iron benefited enough from cheap Indian supplies to earn profits, integrated steel works and specialized producers of pig iron incurred high raw material (related to coal) and labor costs, and thus suffered losses.[xiii] In response, the government enacted higher customs tariffs on steel in 1921 and again in 1926, and began subsidizing the production of pig iron in 1926. Furthermore, the government directed banks to refinance loans to larger firms, with the assurance of government backing in the case of default.

By the mid 1920's, the Japanese iron and steel industry had undergone significant consolidation. All pig iron and integrated producers had been acquired by either the Mitsubishi or Mitsui investment groups, or by Yawata. Leading firms invested the resources gained during the WWI boom to increase efficiency in all areas of production. In particular, investments in pig iron operations introduced larger scale blast furnaces, auxiliary equipment, pretreatment of raw materials, and utilization of by-product gases.

The investments made by the large firms to increase efficiency paid off, and by 1930 Japan's integrated

Map 1. Japanese Iron and Steel Industry Circa 1915



producers had gained cost competitiveness. Their materials cost and labor productivity approached levels comparable with those of steel producers in developed countries. By the late 1920's, the Kamaishi works were producing pig iron at a cost comparable to that of German producers and by 1928, the Yawata Works had increased labor productivity by 40%. The industry gained further traction in 1931 when Japan abandoned the gold standard and the value of the yen plummeted by 40%. This resulted in the cost of finished steel to fall to levels below that of German imports and as result, Japanese steelmakers became highly profitable. Profits were bolstered by government subsidies, which continued until 1934, and ongoing tariffs on steel imports.

Even in the absence of subsidies and tariffs it is likely that the leading steel firms would have remained profitable.[xiv]

In 1934, the Japanese government mandated a merger between the publicly-owned Yawata Steel Company and leading steel producers to form Japan Iron and Steel, a semi-public corporation. Upon its formation, Japan Iron and Steel was responsible for upwards of 97% of the pig iron and 56% of the crude steel produced in Japan. Further changes came in 1937, when in response to WWII, Japanese iron and steel consumption as well as production came under control of the military government. By 1940, annual goals for iron and steelmaking were set by government agencies based on information supplied by the steel industry association, which was staffed by steel firm managers. Through this system, more disaggregated and detailed plans were sent for government approval, which set a precedent for government/steel industry relations during the post war period.[xv] By 1943, Japan ranked fifth in the world for steel production.

Post War Period 1945-1960

The Pacific war ended on August 15, 1945. The territory that Japan occupied during the post-war period was reduced by nearly 50% with the loss of its overseas territories. This loss is significant with regard to its iron and steel production (see Figure 1) because it not only lost the land associated with these areas but also the raw materials they relied upon for industrial use such as iron ore and energy resources. Furthermore, the loss of these regions dealt a huge blow to the Japanese export markets, as Japan had enjoyed the status of a monopoly exporter to the territories it formerly occupied.[xvi]

Figure 1: Production Capacity Lost

Lost Production Capacity From WWII Damage			
Sector	Capacity at Year End 1944	Lost Capacity	Ratio
	Thousand Metric Tons		% Loss
Iron Making	3,461	849	24.5%
Steel	4,467	645	14.4%
Specialty Steel	1,051	234	22.3%

Created from data published by the Japanese Iron and Steel Federation

The war resulted in widespread devastation in Japan, with the bulk of its core infrastructure, such as its administrative, financial, commercial and industrial sectors being left in ruins. Nearly 60% of small- to medium-sized manufacturing enterprises and 20% of large manufacturing plants were destroyed.[xvii] The devastation also marred the iron and steel industry, causing significant losses in production capacity. Another major impact on the ability of the Japanese to produce steel resulted from major shipping losses, as the industry was heavily dependent on foreign sources for its raw materials and fuels. The priority for the sectors was to secure raw materials and fuels in order to resume production at the facilities that still had operational capacity.

The Japanese government believed that in order to secure the future of the country and improve the lives of its people, Japan needed to be rebuilt with a focus on science and technology, and the advancement of the steel industry was of key importance to this aim. In response, the **Committee on Iron & Steel Technology**

was established as an arm of the **Iron and Steel Council** in 1946 and was comprised of experts from academia, the government and the steel industry. The committee conducted a thorough industry analysis that included examining the position of Japanese steel in the world, the relationship between production and raw materials, what the relationship between the steel and chemical industries should be, what system should be adopted as the main production system, how to improve existing steel technologies, and how to develop and strengthen research institutes and train engineers.[xviii] Comprehensive reports were compiled on each of the aforementioned areas and the findings served as the underpinnings of the post-war Japanese steel industry.

A coal deficit held back steel production. In response to this situation, the Japanese government formulated the **Priority Production System** in late 1946, which was subsequently implemented in 1947. The system aimed at increasing the production of coal and steel. This system was supplemented by governmental support through the Reconstruction Finance Bank, which increased loans to both sectors in order to bolster the system. The government strategy was effective, with both sectors showing significant improvements in production by 1948.[xix] Imports of iron ore had been banned until the beginning of 1948. Following the lifting of the import ban in 1948, ore was imported from China, India, the Philippines, Malaysia and the United States. In addition, the Reconstruction Finance Bank began dispersing funds in 1948 to Japan's major steel producers (Japan Iron and Steel, Nippon Lokan, Kobe Steel Works, Fuco Metal Industries and Daido Steel) in order to facilitate the resumption and modernization of production by these firms.

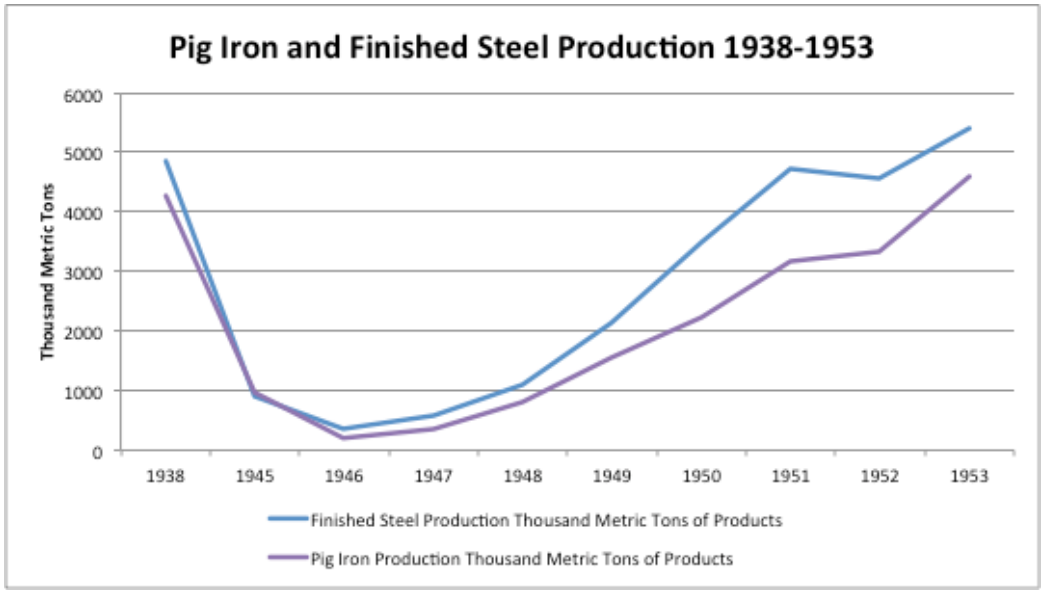
During the post-war reconstruction period, the steel industry had been receiving preferential treatment and subsidies. The 1949 'Dodge Plan' dismantled subsidies and inflicted budgetary austerity in the name of restoring a viable market economy. In addition, Japan Steel was privatized and broken up into two concerns: Yawata and Fuji Steel.[xx] Part of the Dodge Plan was the implementation of a single exchange rate for the yen, prior to which different commodities had different exchange rates. This in effect removed the subsidies.[xxi3] An analysis of the price for pig iron and steel bars exposed the fact that 87% and 72% of the cost of production were covered by subsidies (indirect and direct), respectively.[xxii] This establishment of a single exchange rate resulted in a higher price to consumers which in turn led to a decrease in demand, exposing the steel industry to additional hardship during the midst of their post-war recovery efforts. This put greater pressure on steel producers to rationalize their operations and implement cost reductions.

In 1949 the Ministry of International Trade and Industry (MITI) was formed with the intention of coordinating trade policy and steering the development of Japan's major industries. MITI was also responsible for the provision of important public goods. For example, in the late 1950's MITI invested in new infrastructure projects that revolutionized raw material transport for iron and steel production and made a sizable contribution to industry cost competitiveness. As an institution, MITI also disseminated information to firms about foreign markets, technology, and plans for domestic economic expansion. The role MITI played in the transfer of information filled a gap that had been left by the dissolution of investment groups due to the disruption in financial markets. Planning by MITI and its councils helped encourage parallel, complementary investments in steel, shipbuilding coal and machinery, reducing interrelated costs and thus allowing machinery manufacture to approach cost competitiveness. [xxiii]

[3] "For each commodity, the GHQ decided the dollar price and the yen price separately, so an implicit exchange rate existed for each item. In effect, between 1945 and 1949 Japan had a multiple exchange rate system. Exchange rates for exports (150-600 yen per dollar) were generally more depreciated than exchange rates for imports (125-250 yen per dollar)."

As part of the efforts to reduce the cost of inputs, which had skyrocketed as a result of the implementation of the single exchange rate, restrictions were placed on the use of imported coal, iron ore, pig iron and heavy oil. In response, producers pioneered new production methods that employed coal/coke mixes and a greater reliance upon the use of scrap in the production of steel. Unit consumption of imported materials was greatly reduced and production efficiencies returned to pre-war levels by mid-1951, as shown in **Figure 2**. In addition, there was significant post-war technical guidance provided by top engineers from the US steel industry, which helped to improve all aspects of the processes utilized in Japanese production. In 1950 Japan sent a delegation to the United States to visit and learn from all aspects of iron and steel production techniques being employed by US steel producers. This was a major turning point for the modernization of the Japanese steel industry.

Figure 2: Production of Pig Iron and Finished Steel, 1938-1953



Created from data published by the Japanese Iron and Steel Federation

The outbreak of the Korean War in 1950 and the ensuing involvement of the United Nations-led coalition fighting on behalf of the South Korean forces led to a boost in demand for steel. The wartime demand served a major factor in the steel industry's quick recovery through the provision of market expansion and improved earnings, thus allowing for the expansion and modernization of the production facilities based on the knowledge gained from the US operations. Developing the competiveness of the Japanese steel industry was viewed as central to MITI's industrial development agenda. While the Korean War provided a temporary boost to the industry, the need to secure long-term supply of raw materials was still a requirement for the industry to fully implement its modernization strategy.

Between 1951 and 1953, the steel industry undertook the **First Rationalization Plan** guided by directives from MITI. The plan was intended to be carried out over three years but was extended to 1955 with the total capital expenditure for the period being the equivalent of US$ 6.12 billion in 2015. The plan focused on the rationalization and modernization of the steel rolling mills, with nearly 48% of total expenditures going to these efforts. Iron making was only of secondary concern to MITI, with only ~20% of capital expenditures going to modernizing iron production. At this point, MITI did not see the iron and steel industry as being much more than producing for the domestic market, because it did not believe that Japan could achieve a competitive advantage in exporting steel. Furthermore, MITI was tasked with the overall performance and growth of the entire economy, and believed that too much preferential treatment of the steel sector in the forms of protectionism or boosted exports would hurt domestic heavy industry though higher steel prices. By 1953, the rationalization plan had produced significant results, realizing cost reductions for pig iron (4%), bars (12%), sheets (27%), wire rods (21%), pipes, and tubes (30%).

As opposed to MITI's perception before the rationalization plan, industry executives viewed the modernization as an opportunity to position the steel industry as a significant exporter of steel, while also preparing it to support an industrial structure that would be dominated by heavy and chemical industries.[xxiv] A major component of this strategy involved importing machinery and equipment mainly from suppliers in the US and Europe. In order to support the modernization program, the government implemented tax exemption measures. Imported machinery, destined for iron and steel production, was exempted from import duties along with clauses that allowed for special depreciation in corporate tax according to regulations of the **Tax Special Measures Law.** In addition, reductions were made to the municipal property taxes for participating enterprises.

The **First Rationalization Plan** and the extended modernization program yielded huge gains for the industry as shown in **Figure 3**.

Figure 3: Productivity Increases in Steel Production 1951-1975

Nominal Annual Capacity (1000 metric tons)					
Year	1951	1953	1954	1955	1957
Blast Furnace	3232	3737	3932	5627	6813
Open Hearth Furnace	5056	5906	5953	6018	8922
Electric Furnace	2803	NA	NA	2927	5479
Rolling Mills	11567	13178	13906	15560	19979

Created from data published by the Japanese Iron and Steel Federation

With the end of the Korean War in 1954, the recession in Japan resumed. However, by 1955 Japan began benefiting from an unexpected boost in exports of steel to Europe. The US and British steel producers did not have enough export capacity to meet demand resulting from the reconstruction efforts, so Japan began to fill the gap.

A shortage in a domestic supply for scrap as well as an overall international scarcity resulting from reconstruction efforts further pushed a technological shift from a non-integrated to an integrated steel production system in Japan.

The **Second Rationalization Plan** (1955-1960) was initiated by the steel industry, with the Japan Iron and Steel Federation playing an integral role. The second plan had a much heavier focus on iron production, and resulted in the construction of numerous new blast furnaces. It was accompanied by a plan from MITI to develop a long-term supply strategy for raw materials and capital investment. In an effort to secure a stable supply of iron ore, Mitsui and Mitsubishi started a joint project developing iron ore mines in India. MITI played its part by researching and designing large specialized iron ore transport ships that reduced transport costs by 20%.[xxv]

In 1958, MITI orchestrated a joint venture between steel and shipping companies. The JV was comprised of seven iron and steel firms that became the Japan Iron Ore Transporting Company with loans from the Japan Development Bank. The firms jointly ordered five specialized cargo ships from Japanese shipbuilders. This helped bolster the shipbuilding industry that had suffered during the post-Korean War recession while meeting the needs of the iron and steel industry. This deal illustrated the type of intermediary role MITI played with regard to industrial policy and development moving forward.[xxvi]

The integrated steel plants were located on deep-water harbors and close to major industrial centers. The facilities were capable of receiving the new generation of large ore carriers and the seaboard locations offered freight advantages in handling transportation of both raw materials and exports.

Steel Industry 1960-1970

From the late 1950's through the 1960's the economy of Japan underwent a huge transformation through its transition to a period of high economic growth. The iron and steel industry played an integral part in this transformation by supplying high quality, competitively priced steel to both the domestic and export markets. The cost competitiveness that the Japanese steel industry increasingly achieved served to boost the growth of Japan's heavy industries though the provision of cheap steel inputs.[xxvii]

Between 1960 and 1970, Japanese steel producers rapidly built new integrated facilities in an extremely competitive manner. In 1960, the government announced the **Income Doubling Plan,** which inspired confidence in iron and steel producers that demand would be sufficient to justify their expansion. Firms may also have been inclined to expand rapidly because they perceived, in the event of difficulties, an implicit commitment of government aid, which would favor as it had in the past, firms that were larger and more efficient.

The Japanese steel industry experienced the highest growth rate (12.9%) of any major steel-producing country in the world in the 1960's and early 1970's**.** With its share of world steel production rising from 6% in 1960 to 18% by 1975. This growth was highly dependent on imports (see Figure 4).

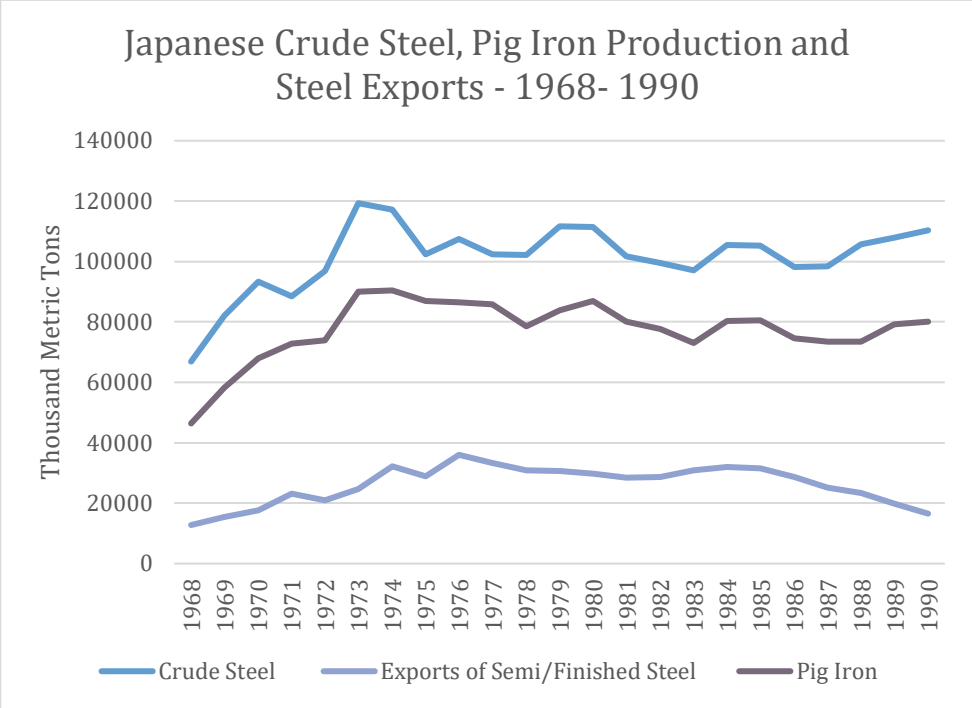
Figure 4: Import dependence of the Japanese Steel Industry

Year	1955	1960	1965	1970	1975
Iron Ore	84.7%	92.0%	97.1%	99.2%	99.4%
Coking Coal	22.0%	35.9%	55.1%	79.2%	86.1%
Iron and Steel Scrap	19.5%	28.6%	15.5%	13.4%	12.9%

From data published by the Japanese Iron and Steel Federation

Through the 1960's, the Japanese steel industry grew with firms aggressively substituting capital for labor. The race to ever-larger and more capital-intensive facilities was fueled in part by MITI, which believed that the route to securing world market share in steel was to invest continuously in more efficient means of production. Moreover, MITI linked the right to build new steel capacity explicitly to efficiency, which was typically linked to labor and materials productivity. The result was a trajectory that emphasized labor-saving technology. [xxviii] By the late 1960's extreme competitiveness within the industry had resulted in severe price cutting which was hurting all of the steel producers' profitability. In response, the government tried to stabilize capacity by supporting a merger between the two largest firms, Yawata and Fuji Steel, to form Nippon Steel in 1970. This was supported by smaller firms in the steel industry because they believed that the new giant would assume the role of strong price leadership.

Figure 5: Japanese Steel Production and Exports



This graph was created from data published by the World Steel Association.

Steel Industry 1970-1990

The Japanese steel industry was confronted with new challenges in the 1970's. The first came in 1971 when US president Richard Nixon implemented the New Economic Program, which ended Bretton Woods and the gold backing of the US currency. Up to that point, the yen had been considered undervalued, with many of Japan's trade partners contending that it granted Japan an unfair trade advantage. The rapid appreciation of the yen, combined with the oil crisis in 1973, resulted in a decline in demand and increase in costs for the industry. The steel industry tackled these challenges by further automating and computerizing their operations. By the mid-1970's Japanese steel producers had attained a significant cost advantage over American and European competitors. Furthermore, Japan's comparative advantage became particularly significant in the area of finished automotive steels, the highest value-added segment of the steel industry.

By 1980, the Japanese Steel industry had reached maturity. While in the 1970's Japanese steel focused on increased automation, during the 1980's the steel mills focused on orienting their production to operate on a just-in-time basis to minimize inventory and drive down costs. This was spurred by the market conditions of the 1980's, with the Japanese steel industry facing lower worldwide demand and intensified competition from low-cost foreign producers such as South Korea. This impact can be seen in the fluctuations in both crude steel production and a downturn in exports from 1980 to 1990 as illustrated in **Figure 5**. This was exacerbated by a

structural change in export markets, with Japan engaging controlling exports to the US and Europe. The industry's suffering in the early 1980's was compounded by the sharply rising yen.[xxix] During this period, the US steel industry responded to the poor market conditions by cutting back on capital spending. By contrast, firms such as Kawasaki Steel in Japan responded by increasing their capital investments despite poor earnings. Throughout the post-war history of the steel industry, Japan has consistently employed the tactic of overcoming market and logistical obstacles through high levels of expenditure on capital improvements and R&D.[xxx] Between 1983 and 1989, the Japanese steel industry devoted an average of 1.5-2.5 percent of total annual sales to R&D, with total R&D expenditures for the industry exceeding $2 billion in 1989. To illustrate this point, the Japanese Steel R&D sector was responsible for the employment of nearly 6,000 scientists and engineers. These investments transformed the Japanese steel industry from a traditional, batch-process heavy industry to a highly automated, continuous-process materials industry.

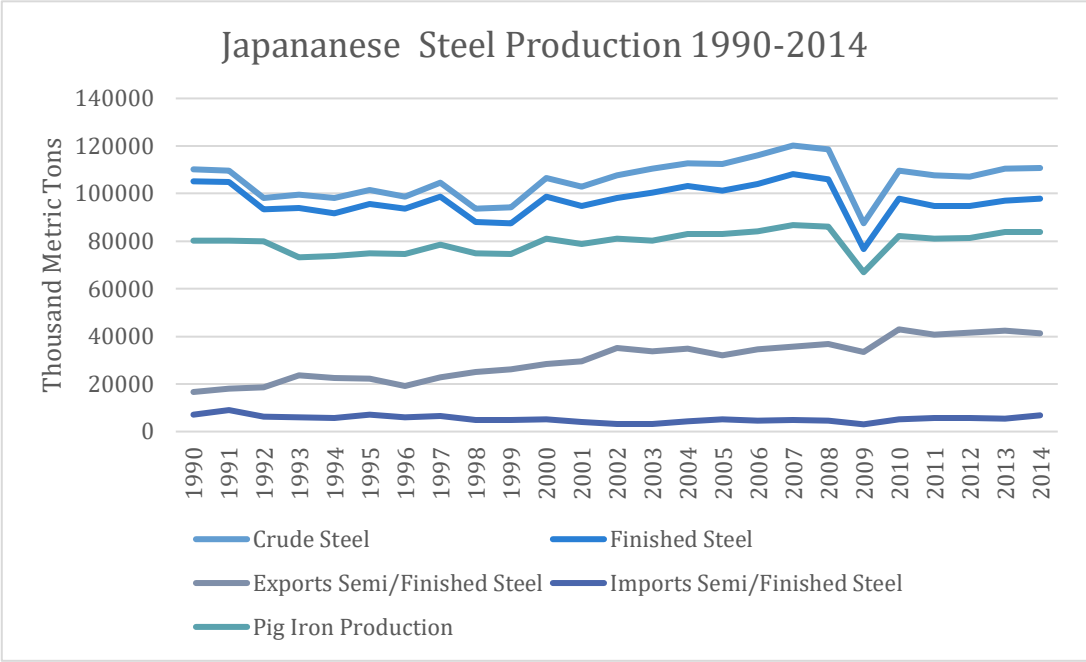
High levels of investment are not the sole factors that pulled Japan out of its slump in the 1980's. The industry also diversified its business to include the production of new materials such as ceramics and specialty plastics. Furthermore, the industry focused on lowering freight and raw material costs. During this time, Japan was purchasing nearly two thirds of Australia's output of iron ore, thus giving steel companies significant bargaining power. The industry further ventured into the transport business with Nippon Steel establishing its own shipping company.

Between 1980 and 1990, Japanese automakers moved a significant amount of its production capacity to the United States. During the same period, the primary Japanese steel producers also established a presence in the American market, generally through capital participation in existing mills and technology transfer.[xxxi] This represents a longstanding linkage that has existed between the Japanese auto and steel producers, with the auto producers demanding ordinary and specialty steels of a quality not rivaled by other world steel producers.

Steel Industry 1990-2015

During the 1990's the industry continued its consistent high levels of capital investment. Point in case, in 1990, the investment in new steel plants and equipment increased by 23.1% over the previous year and exceeded US$ 7 billion. While in 1991 steel production reached its highest levels in a decade, there was trouble in the markets and the ensuing recession was affecting demand. The Japanese steel producers addressed these types of situations as an informal cartel and jointly agreed to reduce production to keep prices stable, a practice that would not be possible in other places such as the US due to anti-trust laws.

Figure 6: Japanese Steel Production



This graph was created from data published by the World Steel Association.

During the 1990's Korea became an increasing threat to the Japanese steel industry. Korea's steel industry grew its production capacity to rival that of Japan, while having significantly lower labor cost, thus allowing it to sell to the world market at a cheaper price. However, despite the predictions that Japan's heyday had passed, this narrative never became reality. Japan's five integrated steel mills continued to thrive throughout the 1990's, despite growing competition from countries such as South Korea and Indonesia. Even with significantly higher labor costs than South Korea, Japan was able to achieve near cost competitiveness with them by the late 1990's while providing what many considered superior steel products.[xxxii] A combination of restructuring, the fall of the yen and increasing cost of production faced by immediate competitors helped the Japanese producers return to profitability in the second half of the 1990's and see significant profits by the beginning of the new millennium. Exports of Japanese steel began a steady climb in the mid-1990's (as shown in **Figure 6 above**) that played a major role in this rebound.

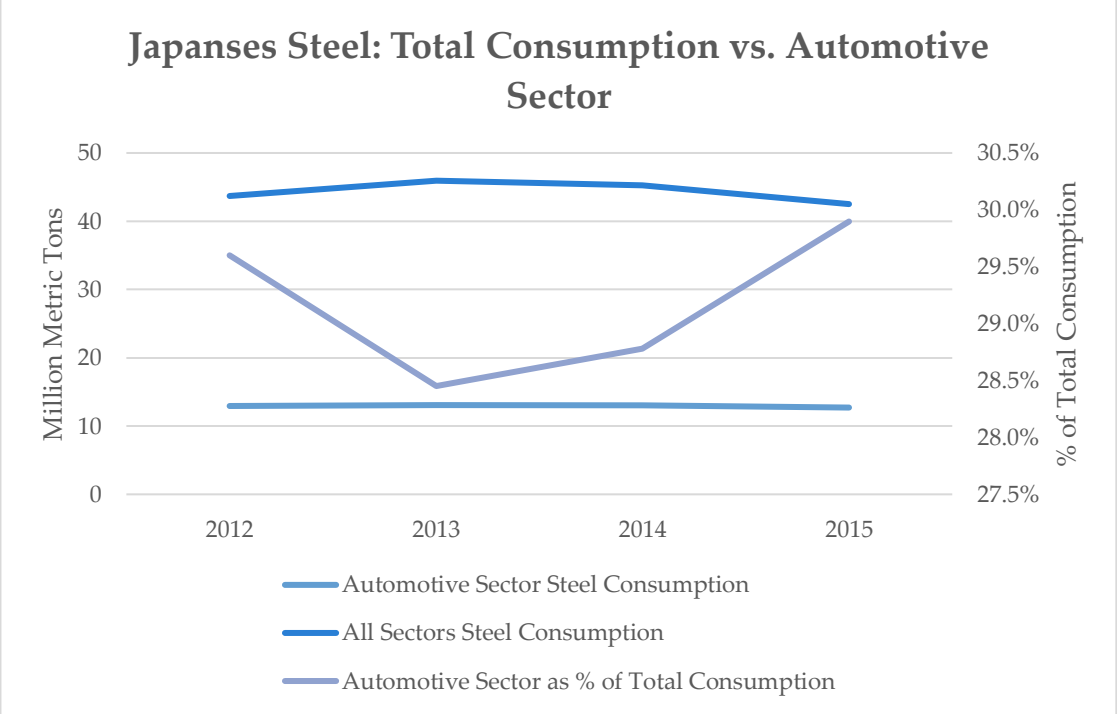
Through targeted efforts, the steel industry was able to reduce costs by 1/3rd between 1992 and 1995. The industry also implemented technology that allowed the substitution of cheaper inputs such as steam coal vs. coking coal and streamlined port operations that have nearly halved the time it takes to fill an on demand order for steel. By the late 1990's, nearly 1/3rd of production was in the form of high quality sheet steel for cars and a little less than a third was in the form of construction steel.

The new millennium marked the beginning of a period of exceptional profitability for the Japanese steel industry and reached its highest production rates in over a decade in 2004. Rising demand stemming from China's building spree coupled with an increase in demand from the ship-building sector helped bolster the

Japanese producers. The steel sector experienced double-digit growth in the first half of the decade and continued to its peak at 120.7 MMT in 2007, nearly an all-time record for the industry.[xxxiii]

The world economic crisis hit the Japanese steel industry hard resulting in the crude steel output plummeting by 26.3% year-on-year to 87.5 MMT, the lowest level since 1969.[xxxiv] However, the industry quickly rebounded, and it has been producing at a rate of approximately 110 MMT since 2010, as shown in **Figure 6.** This rebound was aided by Japan's comparative advantage in producing high value added steel products, especially those used as inputs in the automotive sector, both domestically and internationally. Japan's proportion of high value added steel products, such as those used for the automotive industry, as a total of world production has increased from 76% in 2005 to 83% in 2011. This has been driven by expansion of the Japanese auto makers in emerging economies in Asia. In these markets, high value added steel products from Japan are required because the local steel makers cannot produce the high quality steel products that meet the Japanese auto makers' standards.[xxxv] The Japanese steel and auto industries have long served as complimentary industries, with upwards of 30% of domestic steel consumption going to the auto industry, as shown in **Figure 7.**

Figure 7: Steel Consumption in the Automotive Sector vs. All Sectors



This graph was created from data published by the Japanese Iron and Steel Federation.

Key Conclusions

The Japanese iron and steel industry developed more rapidly and yielded great social returns in part due to government support. The Japanese government fostered the steel industry by protecting the domestic industry through exclusion of most foreign steel imports, controlling over capacity and competitive price-cutting, and allocating the right to increase capacity based on each firm's demonstrated efficiency. MITI has served an important role as intermediary while supporting intra-industry planning and development. Furthermore, the government's implicit acceptance and fostering of producer collaboration facilitated a climate of extreme cost competitiveness. The Japanese production system in general, like the automotive industry in particular, was built around the premise of producing high quality, high value added products with zero defects. All irregularities were eliminated, and all inputs and outputs had to meet rigorous specifications. Furthermore, the steel industry has consistently employed the tactic of overcoming market and logistical obstacles through high levels of expenditure on capital improvements and R&D. The combined impact of these factors is illustrated by Japan's continued role as a top producer and exporter of steel while countries like the United States have fallen by the wayside.

Appendix 1.

Name	Year	Description
Promotion of Iron and Steel Industry Act	1917	The government expanded eligibility for tax exemptions. The law exempted producers from business and income taxes for 10 years. The law also expanded tax exemptions on imported machinery for firms that with a 35,000-ton or more capacity. This law was important because it expanded governmental support to private firms as well, where previously only government-owned firms had received support.
Priority Production System	1947	System aimed at increasing the production of coal and steel through the importation of heavy oil, increased steel production, distribution of steel products to coal mines, and increased distribution of coal to steelmakers.
Committee on Iron & Steel Technology	1947	The Committee on Iron & Steel Technology was established and was comprised of 30 experts from academia, the government and the steel industry.
First Rationalization Plan	1951-1955	The plan focused on the rationalization and modernization of the steel rolling mills, with nearly 48% of total expenditures going to these efforts. Iron making was only of secondary concern to MITI, with ~20% of capital expenditures going to modernizing iron production.
Second Rationalization Plan	1955-1960	The Second Rationalization Plan (1955-1960) was initiated by the steel industry, with the Japan Iron and Steel Federation playing an integral role. The second plan had a much heavier focus on iron production, and resulted in the construction of numerous new blast furnaces and was accompanied by a plan from MITI to develop a long-term supply strategy for raw materials and capital investment. In an effort to secure a stable supply of iron ore, Mitsui and Mitsubishi started a joint project developing iron ore mines in India. MITI played its part by researching and designing large specialized iron ore transport ships that reduced transport costs by 20%.[xxxvi]
Income Doubling Plan	1960	Forecast that crude steel production would increase by 48 million tons by 1970, thus requiring the construction of 30 new blast furnaces.

Bibliography

[i] Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 245.
[ii] Ibid
[iii] iida kenichi pg 449
[iv] iida kenichi pg 453
[v] iida kenichi pg 458
[vi] Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 247.
[vii]Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 249.
[viii] Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 248.
[ix] iida kenichi pg 459
[x]Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 246.
[xi] Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 250.
[xii] Ibid
[xiii] Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 251.
[xiv] Ibid
[xv] Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 252.
[xvi] *Technological Development in the Japanese Steel Industry during Its Postwar Reconstruction*. Tokyo: Iron and Steel Institute of Japan, 1993. Print. Pg 3.
[xvii] *Technological Development in the Japanese Steel Industry during Its Postwar Reconstruction*. Tokyo: Iron and Steel Institute of Japan, 1993. Print. Pg 5.
[xviii] *Technological Development in the Japanese Steel Industry during Its Postwar Reconstruction*. Tokyo: Iron and Steel Institute of Japan, 1993. Print. Pg 13.
[xix] *Technological Development in the Japanese Steel Industry during Its Postwar Reconstruction*. Tokyo: Iron and Steel Institute of Japan, 1993. Print. Pg 10.
[xx]Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 252
[xxi] Kosai, Yutaka, *En no Sengoshi* (The Postwar History of the Yen), NHK Ningendaigaku Textbook, 1995.
[xxii]*Technological Development in the Japanese Steel Industry during Its Postwar Reconstruction*. Tokyo: Iron and Steel Institute of Japan, 1993. Print. Pg 61.
[xxiii] Elbaum, B. "How Godzilla Ate Pittsburgh: The Long Rise of the Japanese Iron and Steel Industry, 1900 1973." *Social Science Japan Journal*10.2 (2007): 243-64. Web. Pg 256
[xxiv] *Technological Development in the Japanese Steel Industry during Its Postwar Reconstruction*. Tokyo: Iron and Steel Institute of Japan, 1993. Print. Pg 139.
[xxv] Yonekura, Seiichirō. The Japanese Iron and Steel Industry, 1850-1990: Continuity and Discontinuity. New York: St Martin's, 1994. Pg. 217.
[xxvi] Yonekura, Seiichirō. The Japanese Iron and Steel Industry, 1850-1990: Continuity and Discontinuity. New York: St Martin's, 1994. Pg. 218.
[xxvii] Yonekura, Seiichirō. The Japanese Iron and Steel Industry, 1850-1990: Continuity and Discontinuity. New York: St Martin's, 1994. Pg. 212.
[xxviii] Lieberman, Marvin B., and Douglas R. Johnson. "Comparative Productivity of Japanese and U.S. Steel Producers, 1958–1993." *Japan and the World Economy* 11.1 (1999): Pg 3.
[xxix] Chira, Susan. "JAPANESE STEEL'S DARKEST DAYS." *The New York Times*. The New York Times, 02 Aug. 1986.
[xxx] "Japan reacts." *Economist* [London, England] 10 Mar. 1984: 73. *The Economist Historical Archive, 1843-2012*.

[xxxi] Oashi, Nobuo. "Academic Commons." *Innovation and Technical Development in the Japanese Steel Industry* -. Columbia Graduate School of Business, 15 Oct. 1991. Pg. 8.
[xxxii] "On a roll." *Economist* [London, England] 11 Oct. 1997: 116+. *The Economist Historical Archive, 1843-2012*.

[xxxiii] "Japan - Steel." *Steel in Japan*. Progressive Digital Media, 2006. *Business Insights: Essentials*.
[xxxiv] "Japan Metals Report - The Updated Q2 2010 Edition." *M2 Presswire* 26 Apr. 2010. *Business Insights: Essentials*.
[xxxv]McCulloch, Russ. "Japanese Steel Drives into Southeast Asia." *Platts* (2014): 8-11. May 2014. Pg. 10.
[xxxvi] Yonekura, Seiichirō. The Japanese Iron and Steel Industry, 1850-1990: Continuity and Discontinuity. New York: St Martin's, 1994. Pg. 217.