MARKET TREND & ANALYSIS

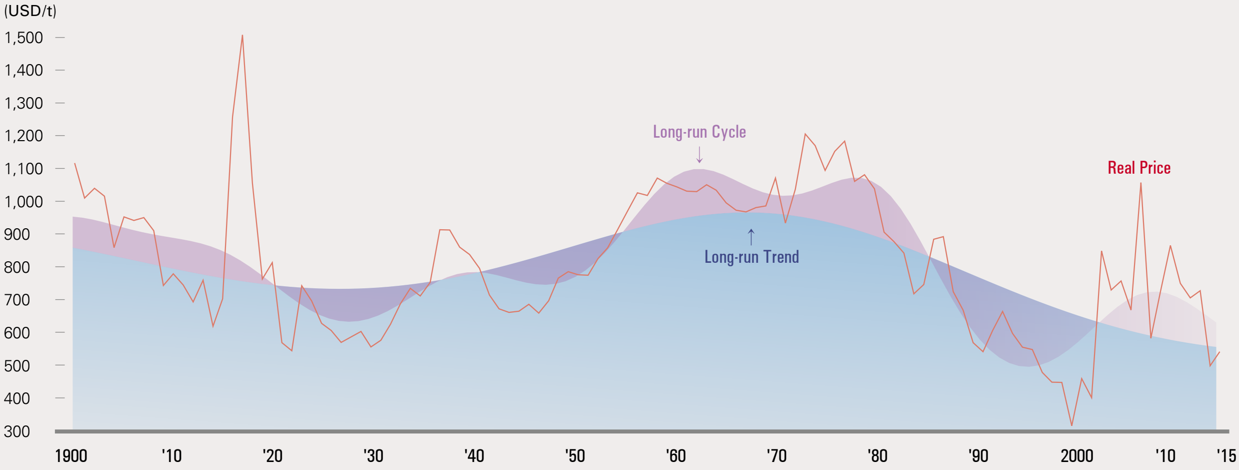
EXAMINING THE PAST 100 YEARS
WHERE IS THE STEEL SUPER CYCLE HEADED?

Dr. Moon-Kee Kong
Senior Principal Researcher
POSCO Research Institute
mkkong@posri.re.kr

Dr. Jun H. Goh
Managing Director
POSCO Research Institute
jgoh@posri.re.kr

Jiho Yoo
Researcher
POSCO Research Institute
kitanjiho@posri.re.kr

Figure 1. Trend-Cycle Decomposition of Real Steel Price



Note : Long-run cycle is extracted by specifying period of 20-70 years using a band-pass filter
Source: USGS, CRU, POSCO Reaserch Institute

Executive Summary

Looking at long-run data of real steel prices over the last 100 years, high volatility in steel prices is not just a recent phenomenon. Steel prices had high volatility from a long time ago and repeated long-run cycles with ups and downs. Real steel prices had long downswings for about 25 years after the first oil shock in the early 1970s, and surged sharply in the 2000s. After a decline in 2010, steel prices began rising in 2016. Then where will steel prices go?

This article assumes that steel prices repeat long-run cycles throughout a long-run trend. If the long-run trend, long-run cycle, short-run cycle can be decomposed from steel price data, it would be helpful to verify this argument and forecast steel prices.

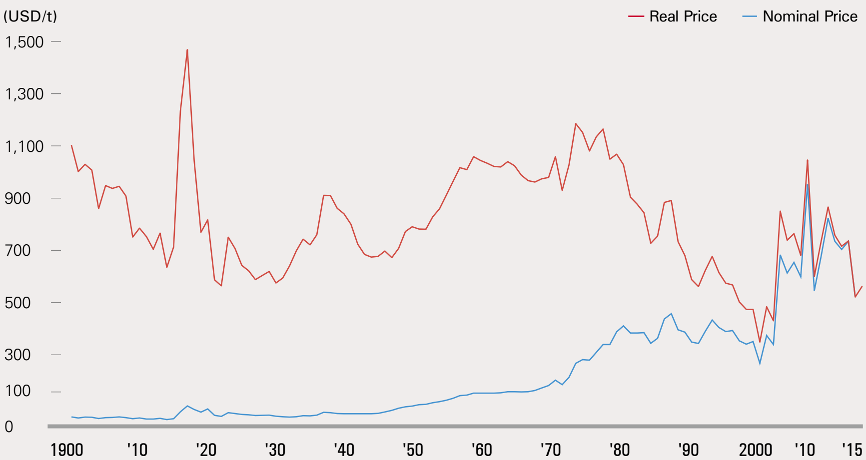
In the 2000s, many experts recognized the existence of long-run cycles with upswings lasting from 10 to 35 years, and termed such cycle as a super cycle. In addition, with the development of a "band-pass filter," it became possible to decompose a long-run trend, super cycle, and short-run cycle from real data. In this article, this concept of a super cycle and the band-pass filter are applied to steel prices, giving important insight into the directions of steel prices.

This article analyzed US real HR price from 1900 to 2016, which for the first time included the latest data until 2016 unlike any other past studies on super cycles . According to this analysis, it turns out that the long-run trend peaked in the early 1970s and declined afterward. The super cycle, which is in its fourth cycle, peaked in 2011 and entered a downward phase. Decomposition of real steel prices suggests four super cycles (1928~1949, 1950~1972, 1973~1996, 1997~). The current fourth super cycle is attributed to rising steel demand driven by China's industrialization and urbanization (China effect) and supply lagging behind the sudden upsurge in demand. Being too optimistic about the prolonged upswings of the super cycle, the global steel industry made excessive investment in facilities. The fourth super cycle failed to maintain an upturn and turned downward prematurely. In the meantime, super cycles of other commodities, including iron ore, crude oil, copper, and aluminum, are quite similar to steel super cycles after 2000, because they share the same cause of a super cycle, the "China effect."

Amid a prolonged low growth of the steel industry, the critical factor to shorten the super downtrend and downcycle is how fast excessive capacity can be reduced. It is also important how fast the economic growth of emerging markets, especially India and the ASEAN, will offset a steel demand slowdown in China.

Although the long-run trend and super cycles are in the downward phase, short-run business cycles have been volatile recently. This will continue for a while. Therefore, steelmakers should pay close attention to short-term business cycles rather than long-run cycles to keep cash flow steady and maximize profits.

Figure 2. US Nominal & Real HR Price Trend



Note: Nominal prices are converted to real prices using CPI (2015=100).
Source: USGS, CRU, POSCO Reaserch Institute

Amid the high volatility of steel prices in the 2000s, the global steel industry began facing mounting uncertainty. Many people think that steel prices had been quite stable and began to fluctuate only in the last 15 years. By nominal price, this misapprehension might seem correct. But looking at real prices over the last 100 years, it turns out that steel prices have had high volatility for a long time, and they repeat long-run cycles of ups and downs. (See Figure 2)

According to long-run data of US real HR prices, steel prices had a long downturn of about 25 years after the first oil shock in the early 1970s, and surged sharply in the 2000s. Then, steel prices fell again after 2010. Current prices remain below the lowest prices before the 1950s. In 2016, steel prices began rising, but no one knows for sure where steel prices will go.

There are mixed views on the recent movement of steel prices. Some might argue that the steel price decline in the last few years is an extension of the current long-run downward trend, while others might claim that the price decline is only a temporary phenomenon of the short-run business cycle and steel prices will recover in the medium- to long-run. Perhaps, an economist might seek a compromise explanation that steel prices are falling in the long-run trend, but have bounced back from the bottom from the perspective of medium- to long-run cycles.

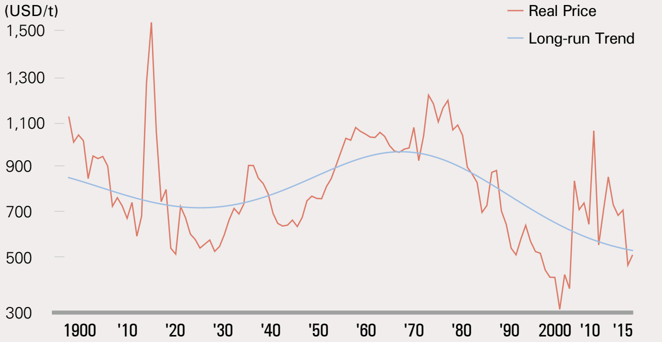
If the components emphasized in the three opinions above (i.e., long-run trend, long-run cycle, short-run cycle) could be decomposed from steel price data, it would help in determining which argument is correct. Using the latest statistical methodology, we show that the real steel price is comprised of "long-run trend," "long-run cycle," and "short-run cycle." The real steel price is assumed to repeat a long-run cycle along the long-run trend as you see in Figure 1. In the 2000s, long-run cycle (trend) was termed "super cycle (trend)."

What is a super cycle?

Since Citigroup analyst Alan Heap released a report titled *"China: The Engine of a Commodities Super Cycle"*[1] in 2005, the term "super cycle" has become popular around the world. Heap defined a super cycle as a "prolonged (decades-long) trend rise in real commodity prices driven by urbanization and industrialization of a major economy." As shown by this definition, early research on super cycles focused only on

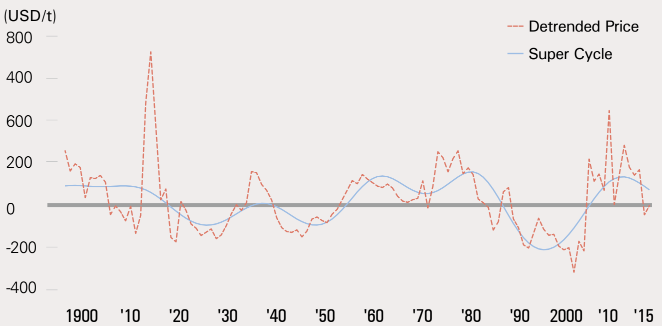
1 Alan Heap, "China: The Engine of a Commodities Super Cycle," Citigroup Smith Barney, March 31, 2005.

Figure 3. US Real HR Price and Long-run Trend



Note : Long-run cycle is extracted by specifying period of 20-70 years using a band-pass filter
Source: USGS, CRU, POSCO Reaserch Institute

Figure 4. Detrended US Real HR Price and Super Cycle



Note: A super cycle is extracted by specifying the period of 20-70 years using a band-pass filter
Source: USGS, CRU, POSCO Reaserch Institute

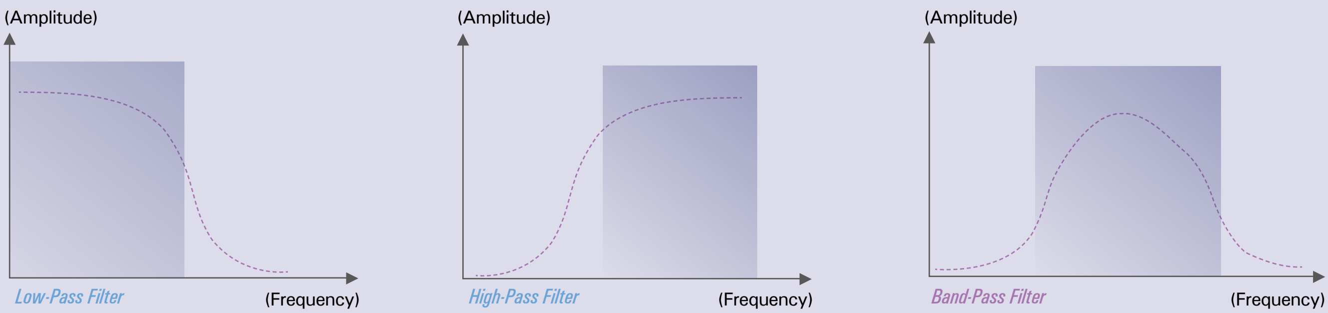
prolonged rises of commodity prices, with little analysis of actual cyclical movement. Even Mr. Heap did not use a strict methodology to extract super cycles from commodity price data. Nor did he define the frequency of super cycles.

The empirical research on super cycles began in earnest when a band-pass filter was used for long-run commodity price data. The band-pass filter is able to extract cycles of different frequencies of short-, medium- and long-run cyclical movement from economic time series, as suggested by Baxter and King (1999)[2] and Christiano and Fitzgerald (2003)[3]. With the introduction of band-pass filters, many economists were able to extract super cycle components from a commodity price time series.[4]

Cuddington and Jerrett (2008) defined the long-run trend as all cyclical components with periods in excess of 70 years, and assumed that super cycles have upswings of 10 to 35 years, taking 20-70 years to generate a complete cycle. The long-run steel prices are decomposed into the following three components:

Long-run price = ① Long-run (super) trend (period over 70 years) + ② Super cycle (20-70 years) + ③ Business cycle (2-20 years)

Identification of Super Cycle by the Band-Pass Filter



In time series analysis, many filtering methods are used to decompose trends and the cyclical components of a time series by specifying a range of frequencies. A filter is a device that passes frequencies within a certain range and rejects frequencies outside that range. By range of frequencies, filters are classified into three categories; low-pass filter, high-pass filter, and band-pass filter. A low-pass filter removes high frequency cycles while retaining only slow-moving components of the data. By contrast, a high-pass filter eliminates very slow moving components

With this decomposition, we assume that the long-run trend is not constant, but rather evolves very slowly over time. Deviation from the long-run trend and super cycle is considered a short- to mid-term business cycle component. The sum of the three components equals the long-run price.

Steel price super cycles over the last 100 years

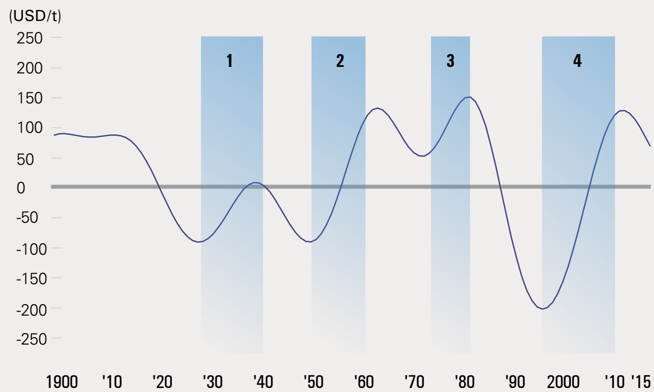
We used the asymmetric Christiano-Fitzgerald band-pass filter to extract a long-run trend and super cycles from long-term US real HR price series (1900-2016). Let's take a look at the long-run (super) trend of steel prices. For this, we used a band-pass filter to extract cyclical components with periods over 70 years.

As shown in Figure 3, the long-run trend of the real steel price shows a downturn after a peak in the early 1970s,

Table 1. Comparison of Steel Super Cycles

	Start	Peak	Trough	Year to peak	Duration
1	1928	1939	1949	12	22
2	1950	1963	1972	14	23
3	1973	1981	1996	9	24
4	1997	2011	?	15	?

Figure 5. Identification of Steel Super Upcycles



2 Baxter, M. and King, R.G., "Measuring Business Cycles: Approximate Band-Pass Filters for Economic Time Series", *Review of Economics and Statistics*, 81 (4), 1999.

3 Christiano, L. and Fitzgerald, T., "The Band Pass Filter", *International Economic Review*, 44 (2), 2003.

4 Representative research include: ① Cuddington, J. T. and Jerrett, D., "Super Cycles in Real Metal Prices?", IMF Staff Paper 55 (4), 2008. ②Jerrett, D. and Cuddington, J. T., "Broadening the Statistical Search for Metal Price Super Cycles to Steel and Related Metals", *Resources Policy,* 33(4), 2008. ③ Erte, B. and Ocampo, J. A., "Super Cycles of Commodity Prices since the Mid-Nineteenth Century, United Nations DESA Working Paper No. 110, 2012. ④ Jacks, D. S., "From Boom to Bust: A Typology of Real Commodity Prices in the Long Run", NBERWorking Paper 18874, 2013.

(i.e., trend) and retains high-frequency components. The Hodrick–Prescott filter widely used in economics is a high-pass filter, and is unable to extract long-run cycles with lower frequencies.

A band-pass filter lets certain ranges of frequencies pass through, while filtering out higher and lower frequency components. Using a band-pass filter, one is able to extract cycles of different periodicities (short-, medium-, long-run) by setting lower and upper bounds. There are two types of band-pass filter: symmetric and asymmetric. Baxter and King (1999) designed a symmetric filter, while Christiano and Fitzgerald (2003) developed an asymmetric filter. The advantage of an asymmetric filter is that there is no loss of a number of observations at the beginning and end of a data sample.

Band-pass filters have been widely used for extraction of long-run commodity price cycles since the 2000s. Jerrett and Cuddington (2008) were the first to use the asymmetric Christiano-Fitzgerald band-pass filter for steel price analysis. Following their lead, we employ the asymmetric Christiano-Fitzgerald band-pass filter to decompose the real steel price.

The real steel price (RP) can be decomposed into three components: (1) long-run trend (RP_T), (2) super cycle (RP_SC), and (3) other shorter cyclical components (RP_O). A super cycle is assumed to last 20 to 70 years.

$$\begin{aligned} RP &\equiv RP\_T + RP\_SC + RP\_O \\ &\equiv RP\_BP(70, \infty) + RP\_BP(20, 70) + RP\_BP(2, 20) \end{aligned}$$

*** BP(20, 70) denotes a band-pass filter with band (20, 70)**

and the real steel price repeats a decade-long fluctuation throughout the long-run trend. However, with this graph alone, it is not easy to judge whether the long-run trend has already hit bottom or will continue to fall. Therefore, in order to more precisely predict the future direction of the real steel price, it is necessary to see the super cycle moving along with the long-run trend.

From the detrended real steel prices (difference between actual price data and the long-run trend), we can extract super cycles with a period of 20-70 years by using a band-pass filter. The super cycles of the detrended real steel prices are shown in Figure 4.

There is strong evidence of super cycles in the real steel prices. The length of a steel price super cycle is about 20-25 years, similar to many other commodity super cycles as shown later. The upward phase of past steel price super cycles lasted for 10-15 years. Decomposition of the real steel prices suggests that there were four long upcycle periods from 1900 to 2016 (1928-1939, 1950-1963, 1973-1981, 1997-2011). (see Figure 4 and Table 1).

Our results show that the current steel price super cycle is the fourth over the past 100 years, after peaking in 2011. The results are not sufficient to determine when the fourth super cycle will hit bottom, but there is a strong possibility that the downcycle will continue for the next several years.

How does a super cycle begin?

In order to forecast the direction of a super cycle, it is important to identify which mechanism past super cycles are generated from. Alan Heap (2005) argued that commodity super cycles are demand-driven, and highly materials-intensive economic activity is the cause of super cycles. However, commodity prices are decided by the demand-supply equilibrium. For this reason, emphasizing only demand side factors can lead to the misjudgment of a super cycle. In keeping with Cuddington and Jerrett (2009),[5] there are three conditions necessary for the occurrence of a super cycle:

① Continuous high demand: Past super cycles were driven by exponential increases in demand (e.g., US economic growth in the early 1900s, around World War II (1940s), post-war reconstruction after 1950s)

② Short-term supply constraints: Short-term supply shortages trigger price increases (A short-term demand surge in steel and non-ferrous metals is very likely to cause supply shortages.)

③ Slow capacity adjustment in response to demand, driving continuous price increase (The speed of long-run supply response is critical for sustained demand expansion to give rise to a super cycle. In the steel industry, capacity expansion lags behind surging demand.)

The global steel market in the 2000s satisfied the three conditions to see another super cycle. First, steel demand in China grew explosively following industrialization and urbanization in the 2000s. Second, the sudden disruption in raw materials supplies caused by natural disasters in 2005 and 2008 constrained steel production in the short term. Third, new capacity increased only slightly until the early 2000s. Considering the demand rise in China, the supply glut was smaller than expected in the early 2000s. After the global financial crisis, China's overcapacity emerged as a serious issue in the global steel industry. Clearly, steel prices in the fourth super cycle, which is still underway, are affected primarily by the ups and downs of the so-called "China effect."

Co-movement with other commodity super cycles

How does the steel price super cycle differ from other commodity super cycles? To answer this question, we extracted super cycles of iron ore, which is most relevant to steel, and other commodities, including crude oil, copper, and aluminum, using the same band-pass filter.

As shown in Figure 6, other commodity super cycles are quite similar to steel super cycles after 2000, because they share the same cause, the "China effect."

5 Cuddington, J. T. and Jerrett, D., "The Recent Metals Price Retreat: So Long Super Cycle?", Presentation for the International Pig Iron Association, March 4, 2009

In particular, the super cycles of iron ore price, which has high correlation to steel price, have moved in sync with steel price super cycles. Real iron ore price is highly likely to stand at pre-1970s levels. The iron ore super cycle recently entered a downward phase after 2013. However, despite its gradual fall, the long-run trend of iron ore price remains relatively high, unlike that of steel price as shown in Figure 1.

Although the super cycles of steel price and other commodity prices have moved in close correlation, there is no guarantee that this pattern will continue, because the steel industry has characteristics that are distinct from other commodity industries. In the case of other commodities, the downturn of a super cycle is caused primarily by technological advancement and an increase in new supply following high prices. One example is shale gas. In contrast, steel (iron) has vast reserves and a high recycling rate compared to other commodities. Therefore, it is practically free from resource constraints. Moreover, due to overcapacity, steel supply can be expanded at any time without technological advancement. For these reasons, one should not rule out the possibility that the steel price super cycle will have a different pattern from other commodity price super cycles.

Factors that influenced steel price super cycles

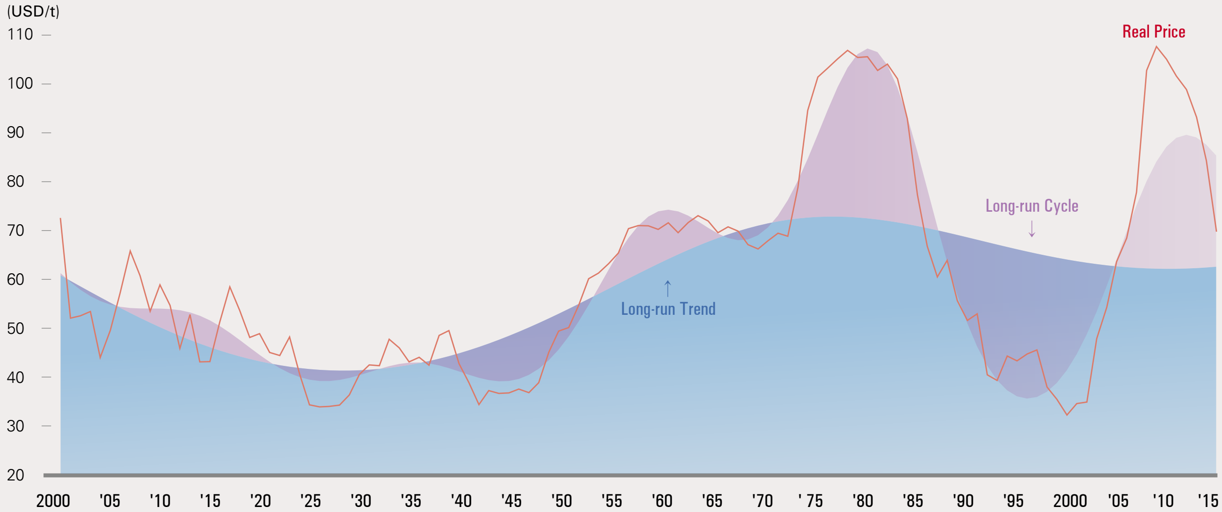
Although most commodity price super cycles, including steel, turned downward around 2010-2012, the debate over commodity price super cycles is still going on.[6]

Figure 6. Comparison with Other Commodity Super Cycles

Note: A super cycle is extracted by specifying the period of 20-70 years using a band-pass filter
Source: USGS, Bloomberg, POSCO Research Institute

6 Refer to these reports for various views on super cycles: "China: Is the Commodity Super-Cycle Over?", CreditSuisse, March 19, 2012, "Commodities Super-Cycle is 'Taking a Break'", South China Morning Post, July 10, 2013, "Why the Commodities Super Cycle was a Myth", Financial Times, September 1, 2015., "So long, Super-Cycle", Financial Times, December 10, 2008.

Figure 7. Trend-Cycle Decomposition of Real Iron Ore Price



Note: A long-run cycle is extracted by specifying a period of 20-70 years using a band-pass filter.
Source: USGS, POSCO Reaserch Institute

Some people may mistakenly conclude that the current downcycle is ending and another price boom is coming. On the contrary, it is time to worry about an ongoing super downcycle. As seen in Table 2, the supply and demand side factors in the global steel market will determine the length and amplitude of the downcycle in the future.

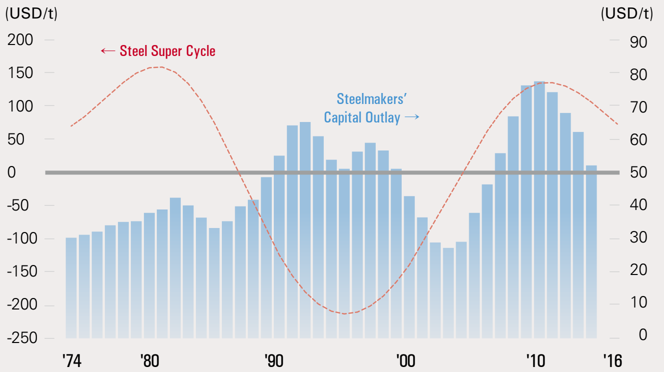
Ironically, the most important determinant of the current super downcycle might be the previous super upcycle. Since Alan Heap (2005), many super cycle believers have extensively discussed the China boom and super cycles, leading to the spread of the term “super cycle.” In the 2000s, the “bandwagon effect” led to excessive investment in the steel industry, resulting in overcapacity.

Figure 8 and Figure 9 give some evidence to support our argument. During the period of the super upcycle in the early-to-mid 2000s, steelmakers’ capital outlay and crude steel capacity surged dramatically, which is presumed to have influenced the downturn of the super cycle thereafter. This finding points to the possibility that supply side factors are more

Table 2. Causes of Steel Price Super Cycle in the 2000s

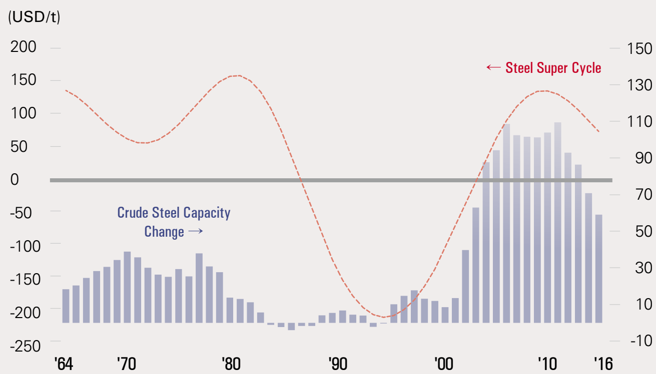
	2000-2011 (Upcycle)	2012- (Downcycle)
Demand	• Surging steel demand following industrialization and urbanization in China • High demand in non-China BRICs nations	• Steel demand growth turns negative as China’s economic growth slows • Demand of emerging countries (India, MENA, Southeast Asia) is anticipated to grow but is not expected to take off before 2020
Supply	• Short-term supply disruption of iron ore, cokes, and other raw materials due to natural disasters • Despite overcapacity in China, obsolete facilities in advanced countries limit capacity expansion	• Global-level discussion just started to address overcapacity • China’s “supply-side reform” is anticipated to progress, but it will take time and energy to implement policies

Figure 8. Steel Super Cycle vs. Steel Investment



Note: Capital outlay is calculated by investment per ton of shipment (3-month moving average)
Source: WSD, POSCO Reaserch Institute

Figure 9. Steel Super Cycle vs. Capacity Change



Note: Crude steel capacity change is based on a 3-month moving average
Source: OECD, POSCO Reaserch Institute

important than demand side factors to reverse a steel price super cycle.

If the current super downcycle is likely to continue for a while, steelmakers might need to pay more attention to short-run business cycles than to the long-run trend or super cycle. Having identified the long-run trend and the steel price super cycle, they should now focus on the shorter business cycles.

Short steel business cycles since the second oil shock

So far, we have analyzed the movement of steel prices over the last 100 years by decomposing the long-run trend and the long-run cyclical components. Now we will analyze the movement of short steel business cycles after 1980. Deviations between actual prices and super cycles are interpreted as the shorter cyclical components that we call "business cycle." To increase the accuracy of frequency and amplitude of shorter cycles, monthly US domestic HR prices after 1980 were used instead of yearly data. Business cycles are extracted by specifying a period of 8-40 quarters using a band-pass filter. (Yearly data would have produced similar results to monthly data, but with less accuracy of short-term frequency and amplitude.)

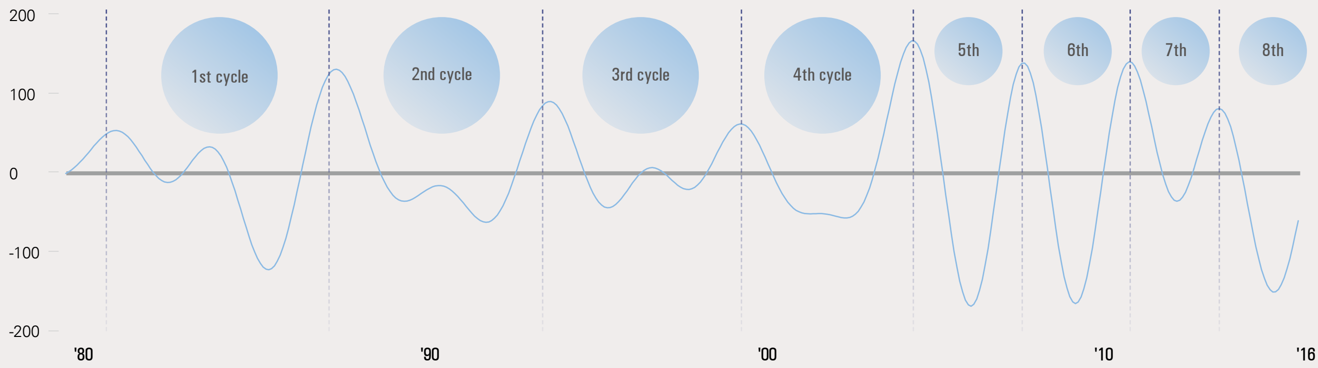
Examination of variations in steel price business cycles from 1980 shows that US real HR price, from the perspective of short-run cycle, may have hit the bottom of the 8th cycle after 2014. According to Figure 10, the length of business cycles became shorter and the amplitude increased around the global financial crisis. This price volatility may be attributed to a demand surge in China in the 2000s, price plunge during the crisis in 2008-09, stimulus packages to overcome the crisis, and chronic demand deficiency amid a prolonged economic slowdown. In particular, the difference between the highest and lowest prices of the 5th and 6th cycles is USD 300/ton, showing roller-coaster-like price volatility.

Where is the steel price cycle headed?

After we have examined the movement of steel cycles over the last 100 years, it is natural to wonder how long-run cycles and short-run business cycles will unfold. As Gangelhoff (2015)[7] said, "the turning points in a super-cycle are a matter of judgment and are only apparent *ex post*," it is extremely difficult to forecast the future, especially in the

7 Gangelhoff, G., "The End of the Commodity Super-Cycle? Implications for USAID Presence Countries", Economics Brief, USAID, December 10, 2015.

Figure 10. Short-term Business Cycles of US Real HR Price



	Points of cyclical change			Length (Months)			Amplitude (USD/ton)	
	Peak	Trough	Peak	Contracting	Expanding	Total Length	Contracting	Expanding
Cycle 1	'81.7	'86.1	'88.1	54	24	79	176	253
Cycle 2	'88.1	'90.1	'94.5	24	52	77	167	153
Cycle 3	'94.5	'96.1	'99.12	20	47	68	134	106
Cycle 4	'99.12	'03.2	'05.1	38	23	62	119	224
Cycle 5	'05.1	'06.10	'08.5	21	19	41	335	307
Cycle 6	'08.5	'09.11	'11.6	18	19	38	304	305
Cycle 7	'11.6	'12.11	'14.2	17	15	33	176	117
Cycle 8	'14.2	'15.9	-	19	-	-	232	-
	Average			**27**	**29**	**57**	**205**	**209**

Note: Real Price is monthly US domestic HR price discounted by US CPI (2015=100). A business cycle is extracted by specifying a period of 8-40 quarters using a band-pass filter
Source: CRU, POSCO Reaserch Institute

middle of an ongoing super cycle.

With great uncertainty about the future, we could posit three or four scenarios. However, we intend to close this article by sketching a predictable future for steel price cycles based on the movement of steel and iron ore price cycles over the last 100 years. Repeating cycles in the past can better predict future cycles than scenario analysis, and provide lessons and implications for the global steel community.

In terms of long-run cycles, assuming an extension of the graph of long-run super trendand cycle decomposition in Figure 1, cycles lasting over the next 10 to 15 years are highly likely to have similar patterns to Figure 11.

In terms of the super trend, questions remain whether the downtrend will continue or an uptrend will begin within a few years. Taking into account of global overcapacity, post-peak controversy in China, and delayed growth in emerging markets after the financial crisis, the argument that the low price trend will continue is gaining ground. Amidst the prolonged low growth of the global steel industry in the next decade, long-run marginal cost of iron ore may also see a downward trend, owing to the continuous increase of iron ore supply and abundant scrap generation especially in China.

The recent super downcycle reflects the price decline after 2010, and may suggest further decline from the per-

The critical factor to shortening the super downtrend and downcycle is how fast excessive capacity can be reduced in the next five to ten years. It is also important how fast the economic growth of emerging markets, especially India and the ASEAN, will offset the steel demand slowdown in China.

Figure 11. Super Trend and Super Cycle Forecast

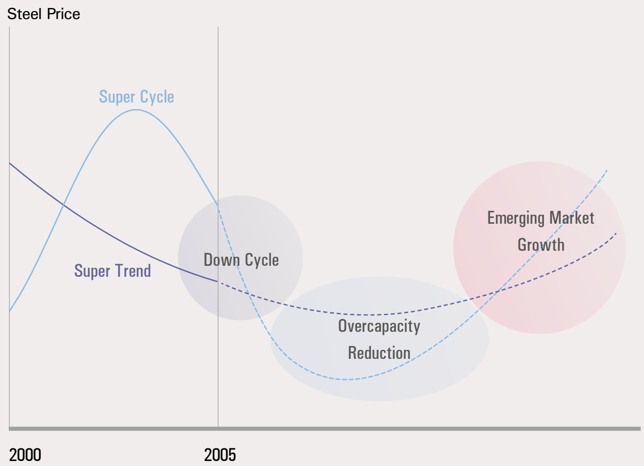
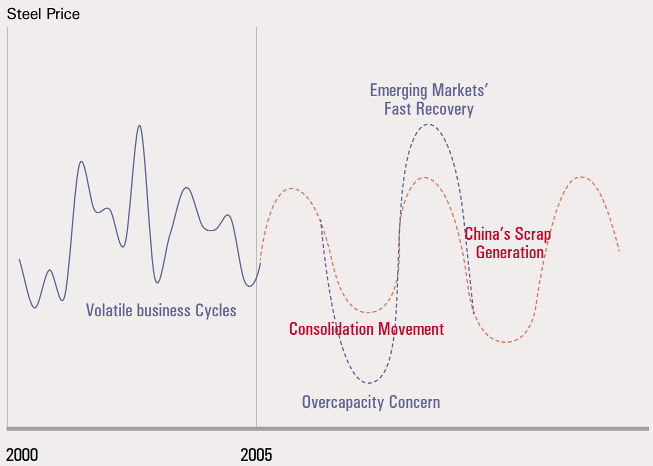


Figure 12. Business Cycle Forecast



spective of long-run cycle. The critical factor to shortening the super downtrend and downcycle is how fast excessive capacity can be reduced in the next five to ten years. It is also important how fast the economic growth of emerging markets, especially India and the ASEAN, will offset the steel demand slowdown in China.

Short-run business cycles have demonstrated high volatility in recent years, and this volatility may last for a considerable time. As shown in Figure 12, the amplitude of short-run upcycles and downcycles will be determined by facility reduction announcement and consolidation policies in major steel-producing countries such as China. Short-run cycles also depend on the sustainability of China's growth and the recovery speed of emerging markets.

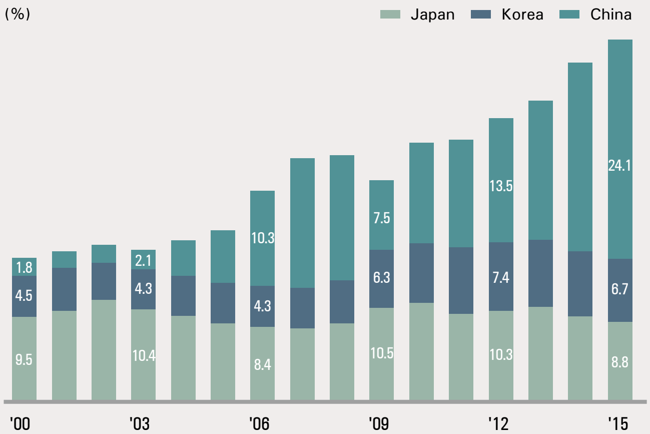
Therefore, even in the overall downtrend, short-run business cycles will show volatility, which will surely have a massive impact on steelmakers' strategic decision-making. For this reason, the steel industry should pay close attention to short-run business cycles in order to keep cash flows maintained. Precise forecasting and insight into short-run cycles are necessary to maximize short-run profits in the downcycle.

Statistical Review of the Steel Trade in Northeast Asia

Chu, Ji-mi
Researcher
POSCO Research Institute
jmchu@posri.re.kr

The global steel export market is riding a wave of change in the face of surprisingly high growth in the Chinese steel industry. Japan used to be the world's top steel exporting country, but it was overtaken by China in 2006. Other major steel exporting countries, including Russia, Germany, and Ukraine, are continuously losing ground. While China has poured massive amounts of steel products into overseas markets for a couple of years in order to overcome sluggish domestic demand and oversupply, Korea, Japan, and other steel exporting countries have been threatened by worsening profitability of their major steelmakers caused by China's encroachment into the global steel market, and plunging steel prices. With competition for steel exports becoming fierce and the center of the global steel structure shifting to China, major global steel mills are focusing on trade markets. Therefore, it is all the more necessary to take a long look at the landscape of the steel exports strategies of Korea, China, and Japan—a key factor of change in the global trade market—and to determine whether changes to the trade market landscape will be sustainable.

Korea, China, and Japan's Steel Exports



Source: worldsteel

Top Global Steel Exporters

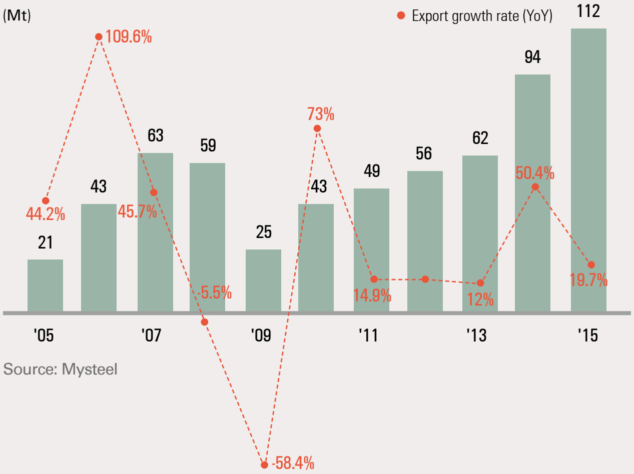
	2000	2005	2010	2014
1	Japan	Japan	Japan	China
2	Russia	Russia	China	Japan
3	Germany	China	Russia	Korea
4	Ukraine	Ukraine	Germany	Russia
5	Belgium-Luxembourg	Germany	Ukraine	Germany
6	France	Belgium-Luxembourg	Korea	Ukraine
7	Korea	France	France	Italy
8	Italy	Korea	Belgium-Luxembourg	Belgium
9	China	Italy	Italy	Turkey
10	Brazil	Brazil	France	France

Source: worldsteel

Korea, China, and Japan, the world's top three steel exporters

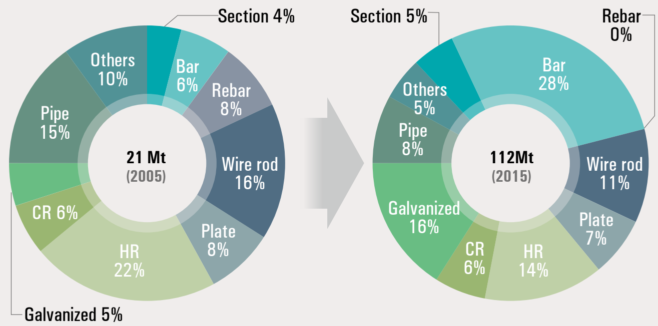
Following the rise of China, the global steel trade market entered a period of structural transition in the 2000s. China used to be a net importer of steel and a "key market" for global steelmakers. However, as its steel production has

China's Steel Exports



Source: Mysteel

China's Steel Exports by Product



Source: Mysteel

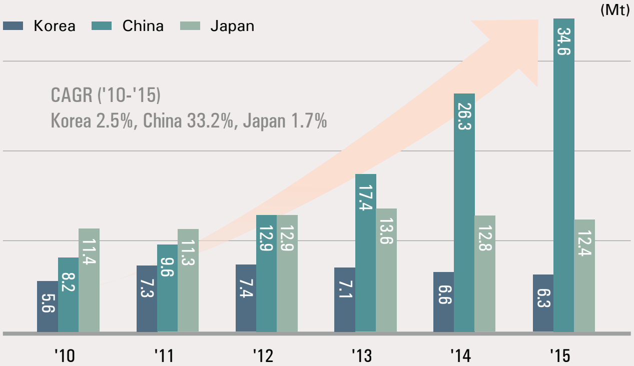
increased through the expansion of infrastructure and the explosive growth of steel-consuming industries such as automotive and home appliances, China has become a net steel exporter. In 2006, China overtook traditional export powerhouses, including Japan, Russia, and Germany, to become the world's largest steel exporting country, and has remained the uncontested No. 1 since 2011. China's share in the global steel trade market was a mere 1.4% in 2000, but rapidly increased to 10.3% in 2006 and 24.1% in 2015. Meanwhile, Korea solidified its footing as one of the world's top 10 steel exporters in the 2000s. After beginning massive investments in overseas downstream facilities in 2011, Korea rose to be the world's third largest steel exporter, taking advantage of the lackluster steel industries of Germany, Russia, and France during the financial crisis. Although Japan has been relegated to second place by China, it still shows prowess as an export powerhouse. As the world's top three steel exporters, Korea, China, and Japan are front-runners in the structural change of the steel export market. The three countries' exports stood at 183.6 Mt in 2015, accounting for 39.7% of global steel trade. They are still expanding into the global market with differentiated export strategies in order to increase their shares.

China diversifies export items and destinations

China has entered a "new normal" era, with its economic growth rate slowing to below 7% and infrastructure investment diminishing. The real estate market lost vitality, and the growth of steel-consuming industries, such as automotive and home appliances, is far below past levels. Under these circumstances, steel consumption fell 5.4% in 2015. However, steel production has grown at a CAGR of 15.4% since 2000, reaching peak overcapacity. The imbalance of supply and demand imbalan has resulted in a continuous decline in China's domestic hot-rolled prices, and aggravated steelmakers' performances. Desperate steelmakers have turned their eyes toward overseas markets in order to address oversupply, selling their products at low prices. Remarkably, China's steel exports grew 50.4% in 2014, to 93.9 Mt, and surpassed 112 Mt in 2015, an increase of 19.7% YoY. Let's take a look at the change in steel export items. In the early 2000s, China exported mainly cost-competitive products, such as steel bars, sections, and plates. With improved technologies, China has continuously made inroads into high-end overseas markets, such as galvanized sheets and boron-added alloy flat, thereby drastically increasing the shares of related items in exports.

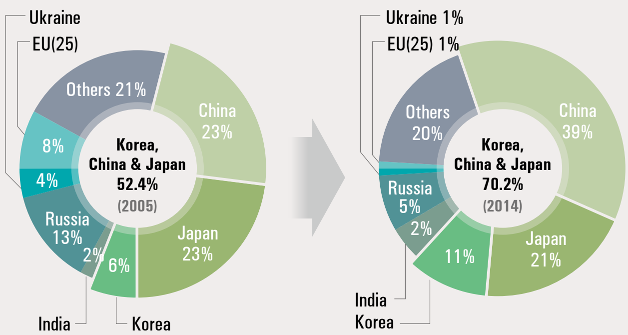
China's major steel export destinations have changed dramatically. In 2005, China's steel exports to Northeast Asia, including Korea, Japan, and Hong Kong, accounted for 40% of total steel exports, but recently China has put effort into expanding exports to the ASEAN market, which is the world's largest import market and a recipient of large-scale investments in infrastructure. As a result, China's exports to the ASEAN have increased noticeably,

Korea, China, and Japan's Steel Exports to the ASEAN



Note: Based on the ASEAN-10
Source: Mysteel, KOSIS, JISF

ASEAN Steel Imports by Country

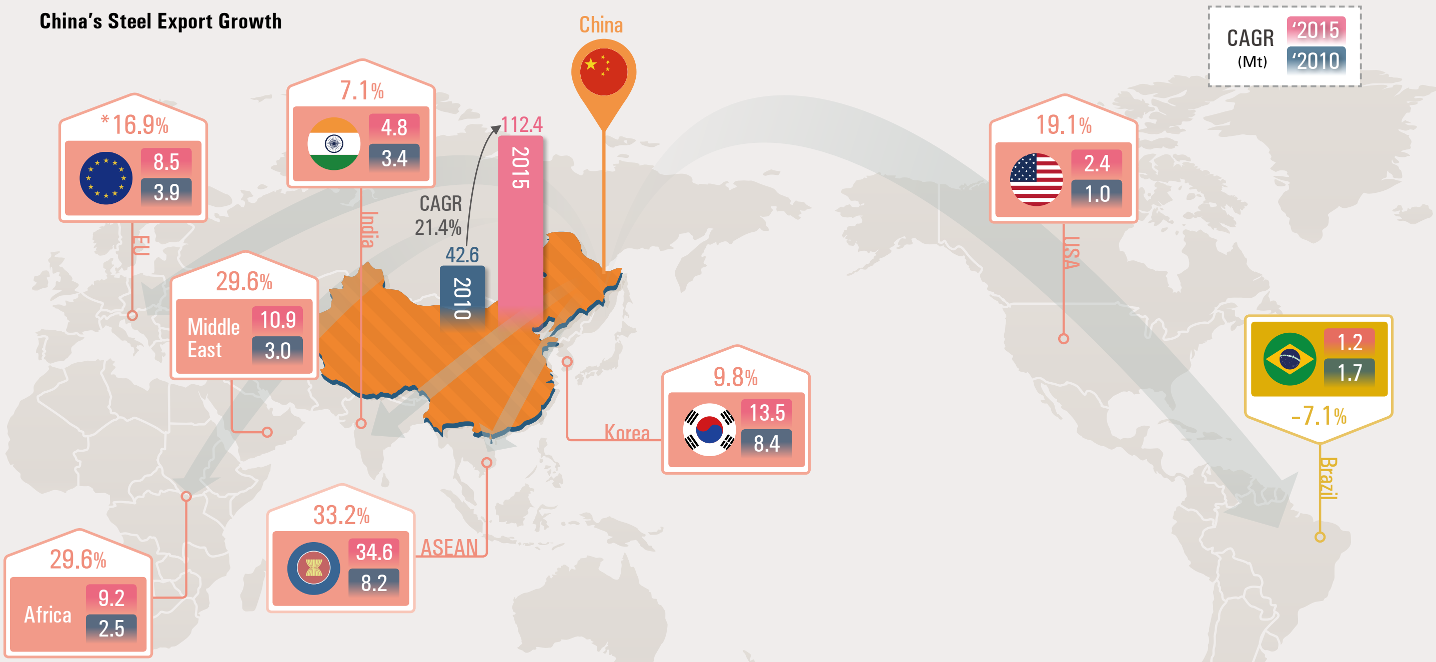


Note: Based on the ASEAN-6
Source: SEAISI

at a CAGR of 33.2% since 2010. In particular, the share of China's steel products in the Philippines and Vietnam rose by 52.5%p and 23.2%p, respectively from 2010 to 2015, because Chinese products emerged as an alternative to Russian products, on which neighboring countries imposed trade restrictions following the Russia-Ukraine conflict over Crimea. As a result, the ASEAN has become the major neighboring export destination for Korea, China, and Japan. The share of the three Northeast Asian countries in the ASEAN-6 (Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam) increased from 52.4% in 2005 to 70.2% in 2014.

China is also expanding its footprint in the Middle East. China's steel exports to Lebanon, Saudi Arabia, and Jordan increased at CAGR of 86.1%, 73.5%, and 35.6%, respectively, from 2010 to 2015. China's steel exports to

China's Steel Export Growth



Note: *denotes CAGR from 2010 to 2015
Source: Mysteel

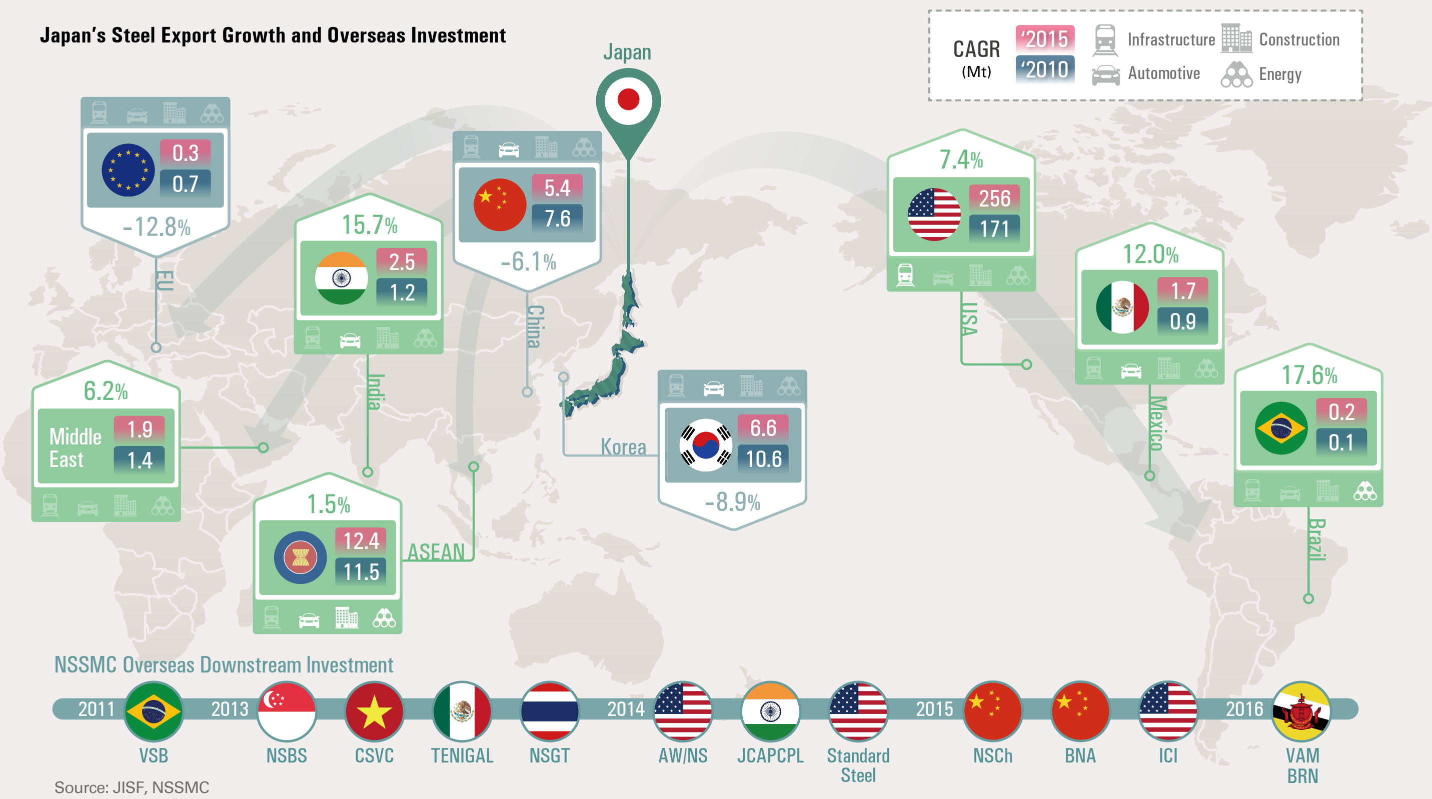
South Africa rose at a CAGR of 34.5% during the same period. From neighboring countries to the ends of Africa, China has succeeded in diversifying export destinations for its bulk supply of steel products.

Japan leaps forward with investment in high-quality steel, taking advantage of locking-in demand

Leading Japanese automakers, such as Toyota and Honda, began establishing overseas production bases in the 1980s, and further expanded into China in 2000. In the 1990s, Japanese mills implemented passive strategies of simply exporting steel materials and high-quality steel products to localized steel-consuming industries, such as automotive, energy, and home appliances. In the 2000s, however, market conditions suddenly changed. Japanese steel mills were forced to find new markets, because their major export markets were attacked by cheap Chinese products, and China and Korea's steel markets gained self-sufficiency. Therefore, Japanese steel mills adopted active strategies to boost the supply of pre-processed original steel materials to local mills invested by the Japanese companies. Japan began operation of downstream facilities in Thailand, based on Thailand's stable demand for high-quality automotive steel sheet, and created new demand through joint ventures with local mills in the USA and Mexico. Accordingly, Japan has expanded its market in the face of heavy inflows of cheap Chinese products; Japan's steel exports to the USA, the ASEAN, and Mexico increased at CAGR of 7.4%, 1.5%, and 12.0%, respectively, from 2010 to 2015.

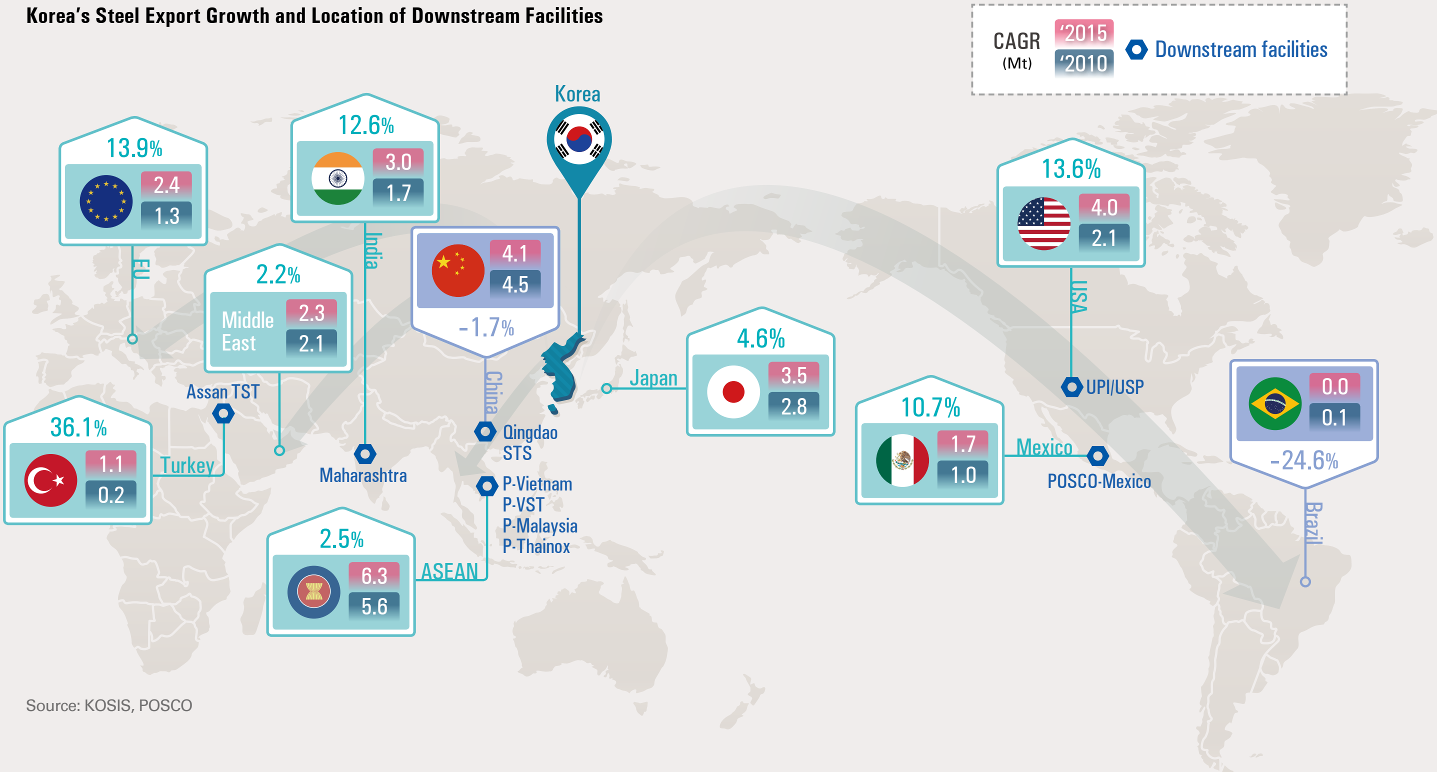
Japan is also actively investing in high-quality steel production, mainly in areas with well-established production networks. In 2014, Nippon Steel & Sumitomo Metal Corporation (NSSMC) implemented overseas downstream operations, including TENIGAL in Mexico, NSGT in Thailand, and NSBS in Singapore, in order to meet demand for and secure supply of high-quality cold rolled sheets exclusively for the automotive industry. It plans to produce high strength steel and advanced high-strength steel (AHSS) at JCAPCPL, a joint venture with India. NSSMC is expanding facilities in the USA. This shows that NSSMC has moved

Japan's Steel Export Growth and Overseas Investment



Source: JISF, NSSMC

Korea's Steel Export Growth and Location of Downstream Facilities



Source: KOSIS, POSCO

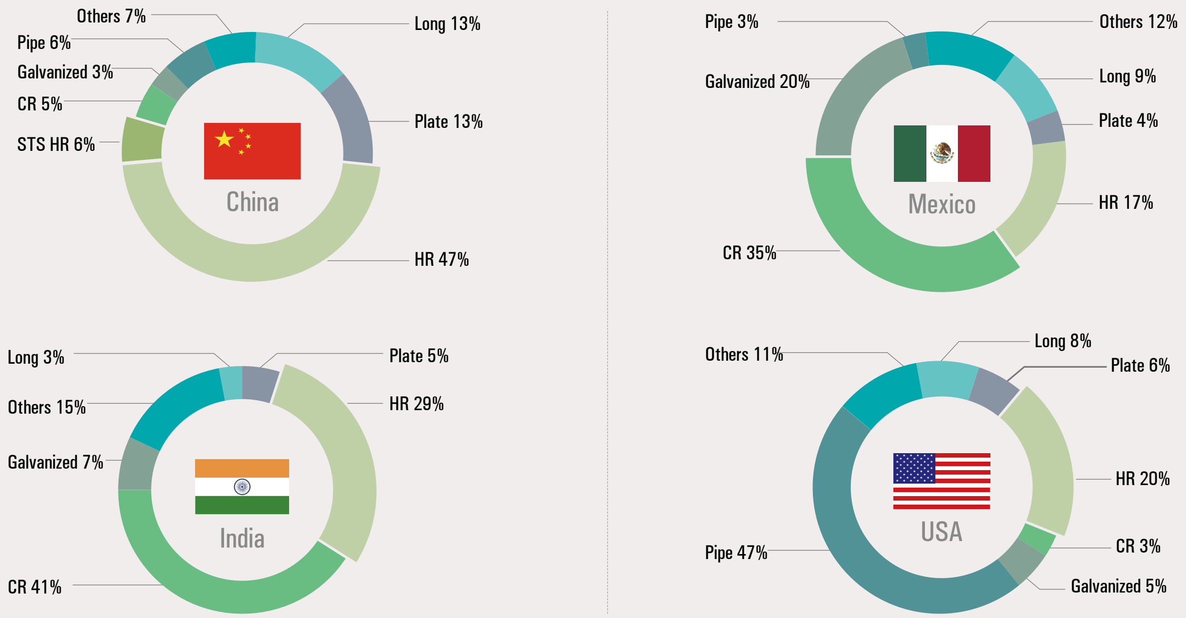
beyond exporting steel materials and high-quality steel products, toward local production of high-strength steel, solidifying its footing in overseas markets.

Korea gears up to meet demand for steel materials through overseas downstream investment

Influenced by sluggish domestic demand due to mature industries and the market dominance of Chinese products, the Korean market became saturated. Desperate for new markets, Korea followed in the footsteps of China, simply exporting products overseas and diversifying export destinations. As a result, Korea ended up in a difficult situation, between China's heavy exports of cheap products and Japan's steel materials and high-quality steel. Korea began investing in downstream facilities in overseas markets, including Turkey, Mexico, and India. Following the successive completion of these downstream facilities in the mid-2000s, Korea gradually opened routes for the supply of steel materials. Korea's steel exports increased a record-breaking 10.5% in 2014.

Once production of galvanized sheets and stainless steel cold-rolled (STS CR) began in Mexico and Turkey, where Korea has made investments in downstream facilities, Korea achieved real results. Korea's steel exports to Turkey and Mexico increased at CAGR of 36.1% and 10.7%, respectively, from 2010 to 2015. P-Mexico began operation of a 900,000-tonne galvanized sheet facility for automotive, home appliances, and construction, in two phases, in 2009 and 2013. Accordingly, the share of its key steel material, cold-rolled (CR) coil, increased to 35% in 2014. Vietnam-based P-VIETNAM and P-VST and Thailand-based P-Thainox began producing CR, STS CR, and electrolytic galvanized sheets (EG). Related steel materials, such as HR and STS HR coil, account for 53% of steel exports. Despite the new downstream operations in Vietnam, Korea's exports to Vietnam rose only 2.6% from 2010 to 2015, owing largely to heavy inflows of cheap Chinese products. Considering Vietnam's high economic growth, there is much room for exports to increase. All in all, Korea is gearing up to increase the supply of steel materials through strengthened local strategies in order to increase steel exports.

Breakdown of Korea's Steel Exports by Country ('14)



Source: KOSIS, POSCO

High Export Similarity Index in Northeast Asia

This article has reviewed the change of the steel trading landscape among Korea, China, and Japan. Has competition for exports intensified among the three countries following the transition of the trading patterns? Taking a look at the Export Similarity Index (ESI), Korea and Japan have been in competition for the last ten years, and China's rapid rise has intensified competition between Korea and China, and China and Japan. Korea and Japan's ESI is high, over 0.7 between 2005 and 2014. Korea and China's ESI increased from 0.55 in 2005 to 0.68 in 2014, and China and Japan's ESI increased from 0.68 in 2005 to 0.7 in 2014.

Competition for steel exports among Korea, China, and Japan has intensified. As the USA, EU, and the ASEAN strengthen protectionist measures for their steel industries, global steel trade will contract and heighten the rivalry among the three countries.

The Export Similarity Index (ESI) measures the extent to which two countries compete by exporting the same products in a certain market. The index ranges from 0 to 1 and a higher value denotes that the composition of exports between the countries is more similar. Export and import data of Korea, China, and Japan are those from the World Steel Export (ISSB) on 27 steel products in 80 countries.

$$\mathrm{ESI}_{ab} = \sum_i MIN[X_i\,(\mathrm{a})/\,\mathrm{X(a)},\ X_i(\mathrm{b})/\mathrm{X(b)}]$$

X_i(a): country a's total export value of product i,
X(a): country a's total export value
X_i(b): country b's total export value of product i,
X(b): country b's total export value

ESI for steel of Korea, China, and Japan in world market

	2005	2007	2009	2011	2013	2014
Korea-Japan	0.70	0.73	0.71	0.76	0.72	0.71
Korea-China	0.55	0.63	0.61	0.69	0.67	0.68
China-Japan	0.68	0.75	0.65	0.70	0.65	0.70