**Financial Risk Management:**
**Heavy Fabrication Company Exposed to Steel Price Volatility**

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*FIN627 class paper, Fall 2009*

## 1. Introduction

Following paper discusses risk management from the perspective of large equipment fabrication company that depends on steel as a key production input (for ex., Caterpillar, Deere, Liebherr). As one can easily imagine, volatility of steel as well as non-ferrous metals can pose a considerable risk to margins and cash flow. Various instruments and strategies have, therefore, been developed in past to hedge against these risks. This article will attempt to provide a basic summary of these instruments and strategies mostly reflecting on author's discussion with commodity trading experts [1].

## 2. Background: Production Chain, Material Flow and Price Formation

In order to understand the risk management approaches one has to map and clarify the production chain including commodity flows and associated formation of the steel price. Figure 1 depicts the process of raw material transformation to finished goods. The steel chain starts with the mining of iron ore which is delivered into a steel mill combining additional raw materials (coke and limestone) in a blast furnace. From blast furnace molten iron then goes into a basic oxygen furnace to create crude steel (over 65 percent of the world's steel is produced via this traditional method). The balance of steel production is produced by so-called 'mini-mills', which use high iron materials, mainly steel scrap [2].

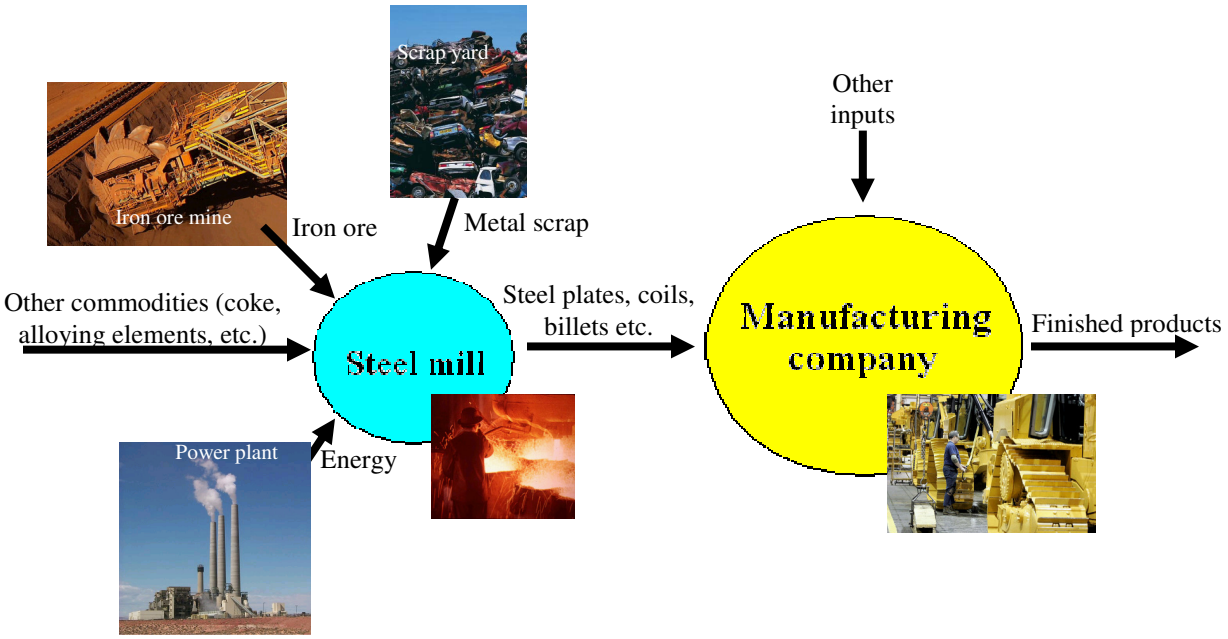


*Figure 1. Generic production chain for large equipment manufacturer.*

From the perspective of price formation, often manufacturing companies and steel making plants are found to be separate entities. Prices of semi-finished steel products are then determined competitively [1]. Although steel is very abundant commodity, it is difficult to develop universal pricing and open markets [2]. As there are many different physical and chemical properties relating to steel, no single global price for steel.has been established. According to article [2] there are more than 3,500 steel products that may not have unique chemical composition but will exhibit unique properties. Semi-finished steel products fall into one of two broad categories; (i) flat and (ii) long products [2]. Flat products (i) include rolled coils, plate and coated sheet, while (ii) long products consist of rebar, structurals, rails and wire rod. Further detail is provided by Figure 2 visualizing the transformation process in a generic steel mill.

Variety of properties and shapes often leads to scarcity scenarios. If manufacturer requires certain combination of category (shape) and properties of steel such option may be available just by one or few steel producers in given region. Difficult to predict volatility and price growth is then frequently rooted in mono- or oligo-polistic market with insufficient steel producer competition. It is noted that markets for pure metals such as nickel, copper, chromium, silver etc. are well defined / flowing as the properties are largely defined by specific chemistry.

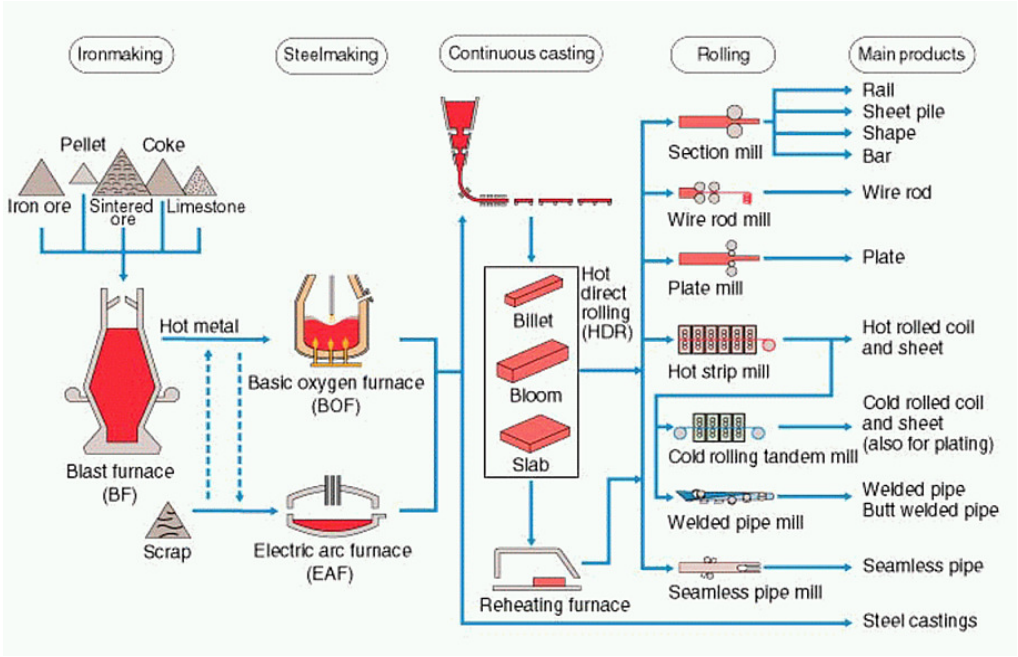


*Figure 2. Cross-section of steel-making producer. (source: [1])*

Similar situation as with the steel market, and perhaps even more so, exists with iron ore mines where the market is very concentrated (few large mines controlling world production). Iron ore prices are not set on the "production cost + margin" basis, rather are governed by premium pricing model. Worth noting is that also another commodity resembles similar pattern. Crude oil is being traded at levels exceeding production costs

more than ten times (production cost on 1 barrel in OPEC is ~$5). Price formation for the semi-finished steel product is depicted in Figure 3.

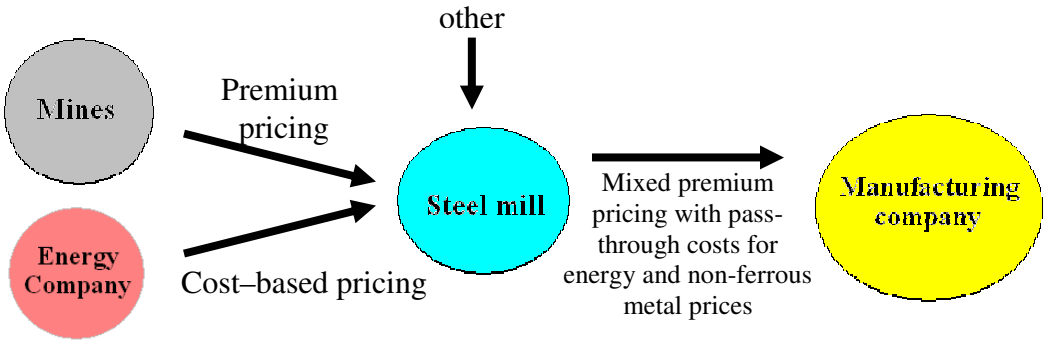


*Figure 3. Semi-finished steel product price formation.*

World wide production of crude steel exceeded 1.3 billion metric tons in 2007 representing nearly one $1,000B of value [2] (double of all other major metals industries combined, in terms mass - 15 times larger than all the other industries). The U.S. domestic steel sheet market is comprised of about 11 major steel mills that produce more than 50 million tons of sheet products annually [2]. Key worldwide players are listed in Table 1, US steel – largest domestic producer ranked on 10$^{th}$ place.

| Rank | 2007 steel production | Company name (Country) |
|---|---|---|
| 1 | 116.4M ton | Arcelor Mittal (Luxembourg) |
| 2 | 35.7M ton | Nippon Steel (Japan) |
| 3 | 34M ton | JFE (Japan) |
| 4 | 31.1M ton | POSCO (South Korea) |
| 5 | 28.6M ton | Shanghai Baosteel Group Corporation (China) |
| 6 | 26.6M ton | Tata Steel (India) |
| 7 | 23.6M ton | LiaoNing An-Ben Iron and Steel Group (China) |
| 8 | 22.9M ton | Shagang Group (China) |
| 9 | 22.8M ton | HeBei Tangshan Iron & Steel Group (China) |
| 10 | 21.5M ton | US Steel Corporation (United States) |

Table 1. 10 largest steel producers in the world (2007), source [3].

## 3. Definition of Risks Associated with Steel Price Volatility

Only small fraction of businesses can make profit without accepting some level of risk. Risk can simply be defined as uncertainty of future outcome that will either worsen of improve position [4]. Clearly, if future change doesn't lead to worsening or improvement of financial position such uncertainty cannot be identified as risk.

Specifically then, risk caused by volatility of commodity prices (volatility being the potential rate of change of future prices) is commonly expressed in terms of standard deviation of past prices as summed up in Fig. 4.

Financial risks (exposure) of a company depending on steel (metal in general) as key production process input can be associated with (i) either cash flow / liquidity problems due to sudden increase of commodity prices and (ii) potential loss of margin of finish product and overall profitability.

| Standard Deviation, A Measure of Risk |
|---|
| Risk = the standard deviation of price movements |
| $= \sqrt{(\sum(\Delta pi - p)^2)/(n-1)}$ |
| where: pi = prices of an individual metal |
| $\Delta pi = pi/pi-1$<br>$p$ = Mean of the $\Delta pi$ |
| n = the number of $\Delta pi$ in the calculation<br>The intervals between the price measurements depend on the context, but daily prices are typically used. |

*Figure 4. Risk associated with volatility of given commodity is usually gauged by standard deviation. Source [4].*

Proper understanding of historical prices is used for future projections of price fluctuations, which then in turn drive cost of hedging instruments outlined in Paragraph 4. For example, daily price fluctuations of aluminum price on London Metal Exchange in 1989-1999 are shown in Figure 5. Figure 6, then depicts steel price evolution of steel prices on European, US, Chinese and world markets.

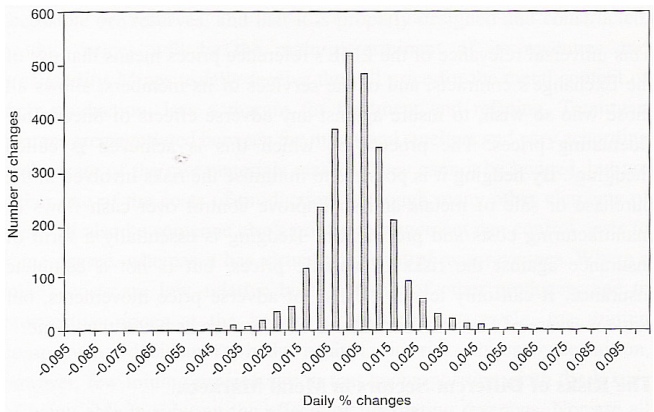


*Figure 5. Daily fluctuations of aluminum prices traded on LME in 1989-99. Source [4].*

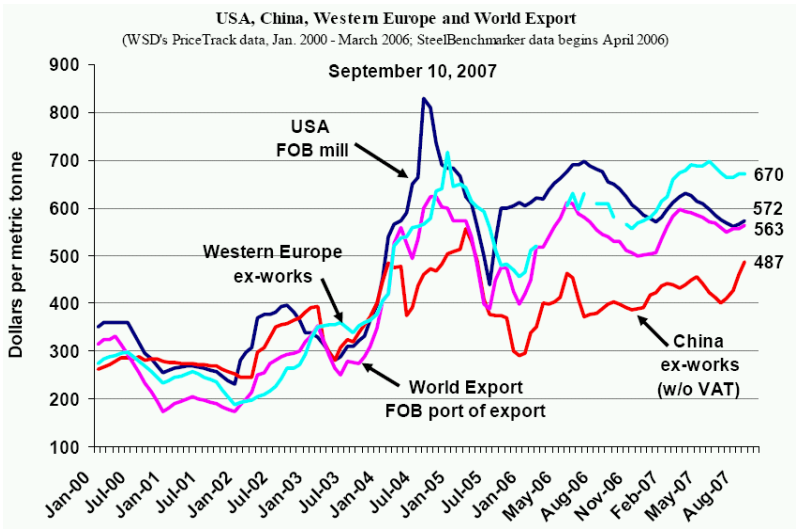


*Figure 6. Spot price evolution for low alloy hot rolled band steel between 2000 and 2007.*

Metal price volatility is a result of many factors [5]. As discussed in Paragraph 2 one of the main contributors is change in demand curve associated with increased economic activity and technological developments [4]. Namely, world prices have been strongly influenced in the last 15 years by growth of Chinese economy [6]. Other mechanisms behind volatility involve speculations on metal exchange markets, currency fluctuations, changes in production costs and costs of inputs (such as energy, alloying elements or iron ore costs).

## 4. Risk Management Tools

Manufacturing companies working with steel inputs have several instruments and approaches at their disposal. The most important are

- Physical hedging, whereby a manufacturing company maintains inventory levels sufficient to cover shorter term (1-6 months) price fluctuations
- Hedging with metal commodity derivatives, if available (non-ferrous metals derivatives are abundant and some derivatives are available for limited steel products). Basic derivatives include options (put, call) and forward contracts (futures).
- More transparent trading with market indices. For example, CRU indices are compiled independent consultancy group called CRU from a weighted average of steel industry prices (from realized trades). Indices are used during trading as lighthouses for setting prices and gained significant traction on the last 10-15 years [1].
- Development of long term contracts with steel mills securing "production cost+margin" based pricing.

Growing popularity of index based trading is clearly discussed in article [2]: "The use of index-based pricing programs by steel sheet producers in the USA has grown dramatically in recent years, in tandem with the increase in steel price volatility. In 2004, very few physical market transactions were index-based. In 2008, estimates are that nearly 25-30 percent of transactions (worth around $15 billion) will reference an independent assessment of market prices, the majority using price assessment as determined by CRU Indices. The market's acceptance of the CRU price assessments for U.S. Midwest domestic HRC (hot rolled coils) supports the CME Group decision to list financial contracts based on this market price."

Finally it is worth noting that steel product derivatives are very new instruments. As of today derivative contract are available on major markets for only 2 types of product: (i) steel billets through London Metal Exchange (LME, offered first time in Feb 2008 [7]) and (ii) hot rolled coil steel through NYMEX (CME Group) has listed a future contract basis the price of 'U.S. Midwest Domestic HRC Steel'.

## 5. Realistic Risk Management Strategies

### *5.1 Strategies if financial derivatives are available*

Preferably, companies use derivatives (futures and options) to hedge again potential fluctuations of commodities. For example, it is a common practice of large equipment

companies [1] to use options and futures for hedging volatility risks of non-ferrous metals used in manufacture of aluminum alloy turbocharger wheels, copper wiring etc. One of the most notoriously known examples of successful hedging (although not with metal commodities) is Southwest Airlines [8]. In 2005 Southwest was paying $26 per bbl. while the market price being paid by it's competitors was $55 per bbl.

Manufacturing company considering hedging against risk of input commodity has in general three options: (i) purchase call options contracts, (ii) purchase of forward contract and (iii) not to hedge at all. All three options are depicted in Figure 7 (assuming $1,200 as exercise price), where on horizontal axis is market price at maturity and vertical axis designates actual price paid by the company. One can observe that for ultimate market prices below strike price no hedging will result in most favorable pricing, whereas for market prices above this limit best position is reached with futures contracts. Three scenarios of ultimate market prices of $800, $1,020 and $1,200 are summarized in Table 2 highlighting the most favorable positions with bold blue font. Concept of hedging combination has been used to optimize tradeoff between risk and potential benefits. For example, if company expects (without certainty) commodity prices dropping in future, it may choose to purchase derivatives for only ½ of the volume of material needed and evenly split it between call options and futures. Resulting purchase price characteristic is a compromise of between derivatives and position without hedge as shown in Figure 8.

Another risk management approach used by companies is called MinMax strategy. If manufacturer finds call options prohibitively expensive to purchase he may find source of financing in selling puts to the commodity (steel) producers. This strategy consists in trading the opportunity of some beneficial price movement for reducing the price of protection through call options [2].

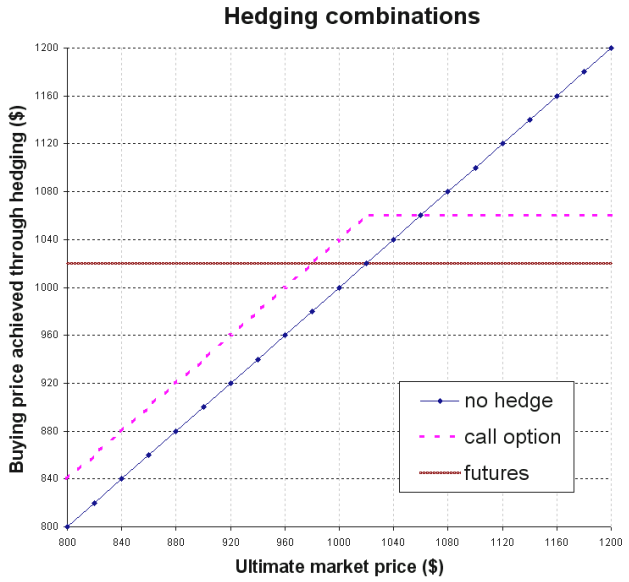


*Figure 7. Graph depicting realized price vs. actual market price for purchase of steel by manufacturing company using different hedging options. (the lower buying price the better).$1,020 strike price is assumed.*

| Ultimate Market Price | Options | Futures | No hedging |
|---|---|---|---|
| 800 | 840 | 1020 | **800** |
| 1020 | 1060 | **1020** | **1020** |
| 1200 | 1060 | **1020** | 1200 |

*Table 2. The outcome of three ultimate market price scenarios (blue=best outcome).*

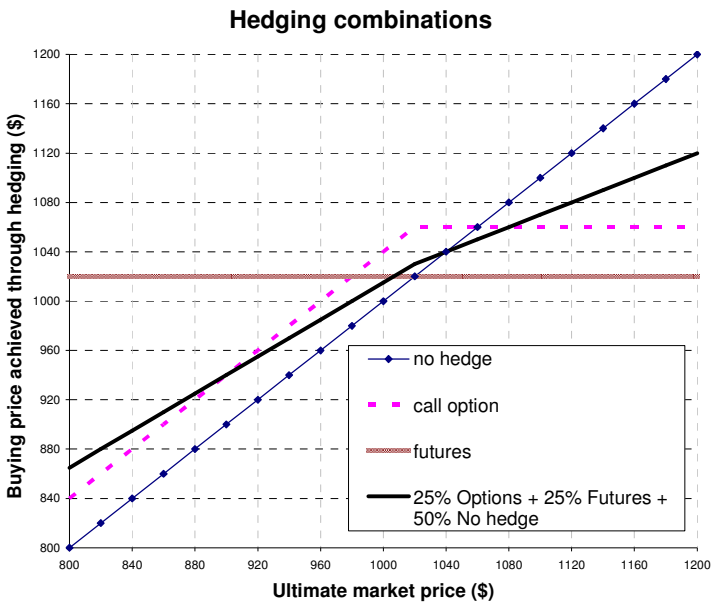


*Figure 8. Price realized for the 50% no hedge-25% options-25% futures hedge combination.*

### *5.2 Strategies if financial derivatives are **not** available*

If derivatives market is not available, manufacturing companies tend to use physical hedging in combination with relating transactions to CRU index [1]. From longer term perspective a remedy may be found in reaching long term agreements with steel mills securing production cost + margin pricing. This is, however, not always possible and companies may need to accept these long term volatility risks. Additional strategies occasionally employed may involve purchase of stake in steel mill or purchasing call options for steel mill stock (if available) or forging multi-lateral arrangements involving (a) iron ore mine, (b) steel mill and (c) equipment fabricator. Example of such arrangement would be exchange of equipment for iron ore produced and a mine and subsequently provided to the steel mill.

In some instances commodity market price may exhibit strong correlation (perhaps in short run) with some steel producer's inputs. If such correlation is sufficiently reliable ($R^2$ >0.8), the fabricator may be able to offset the volatility risk by hedging/prepaying this input. Such approach has been used for energy prices [1]. It is noted that no correlations are usually found between CRU index and iron ore prices.

## 6. Summary

Hedging against input volatility risk from the perspective of large equipment fabricator is a difficult problem. Namely, since steel commodity market is still in early development stages companies often have to employ other strategies than relatively straightforward engagement in derivatives trading. Successful approach to balancing volatility risks and potential company profitability consists in combination of (i) physical hedging, (ii) careful planning of commercial/financial transactions as well as (iii) development of good and transparent business-to-business relationships with suppliers.

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