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Investment decision in integrated steel plants under uncertainty

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ABSTRACT

Steel is an alloy composed of iron and carbon for which there are two main large-scale production processes: using iron ore and coal as raw materials through a method known as integrated plants with blast furnaces and using iron scrap melted in electrical furnaces, also known as mini-mills or semi-integrated plants. The production in integrated plants typically implies greater investment, but is more cost-competitive as it provides greater economies of scale. The disadvantage of this method is that the furnaces basically need to work almost continuously through their life span, thus reducing the flexibility of production adjustment to market demands. To attenuate this problem, huge investments in lamination assets are commonly made, generating the possibility of production diversification and valuable switch options. This work values an output switch option in a hypothetical integrated steel plant composed of a blast furnace and a hot laminator. Results show that this option can generate a significant increase in the NPV of blast furnace plants. Results also emphasize the importance of correctly choosing the stochastic process for the underlying uncertainty and the effect it may have on the switch option value.

1. Introduction

Steel is an alloy composed of iron and carbon. There are two main large-scale production methods. The first involves using iron ore and coal as raw materials in a process known as production in blast furnaces or integrated plants. The second method uses iron scrap (or solid pig iron) melted down in electrical furnaces known as mini-mills or semi-integrated plants.

In the integrated plant process, coal has two functions: as a fuel and as a reducer. As a fuel, coal provides the high temperatures – approximately 1500 °C – that are fundamental for iron ore fusion. Acting as a reducer, coal helps to remove the oxygen from iron, allowing the iron to combine with the carbon. Several steps are necessary before it becomes crude steel in the form of slabs or billets. Generally, the production of steel in blast furnaces implies a greater initial investment, but the process proves to be more cost competitive. The main disadvantage is the almost continuous operation of the blast furnaces, which decreases the possibility of reducing production scale when the demand decreases.

Steel is a commodity with significant price volatility. As an example of this variation, the price of a ton of hot rolled steel in the U.S. market fluctuated from approximately US$250.00 to US$1200.00 between January 2000 and September 2009. Moreover, steel demand is very unstable with great variations during economic booms and recessions. These variabilities, both in prices and quantities, can significantly affect steel companies' turnover and, consequently, their profitability.

As a way of attenuating the effect of these price and demand variations on the plants' profits, it is common for steel companies to adopt an output product switch strategy. Different steel products are demanded by distinct sectors of the economy, and the variations in their prices, even though correlated, are not identical over time. Aiming at taking advantage of this flexibility of product/market demand, steel companies invest in lamination assets – the step of production in which the steel shape is defined – generating valuable product switch options. Although it is intuitive that these options appear to have a significant value, it is important to know how to value them to correctly appraise the necessary investments in lamination assets required to create them.

This article values the incremental benefit of product switch options in integrated steel plant projects. To achieve this, a hypothetical integrated plant composed of a blast furnace and a hot laminator is considered. Using a Monte Carlo simulation, the switch option value

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is estimated, considering two different stochastic processes – Mean Reversion Model (MRM) and Geometric Brownian Motion (GBM) – as price behavior models.

This paper is structured as follows: in the second section, a bibliographic revision on real-option valuation of projects is made; in the third section, we present a steel sector overview; in the fourth section, the case study is presented with the model and results; and in the fifth section, we conclude.

2. Project valuation with real options theory

The traditional view of finance on corporate investment is that companies would only invest in projects when the expected return is higher than its cost of capital. Based on this proposition, the methods known as Internal Rate of Return (IRR) and Net Present Value (NPV) are the most frequently used techniques in corporate project valuation. Both tools use expected cash flows, but NPV is considered a better approach as it uses a risk-adjusted discount rate and indicates the value created by the project to investors. It also allows the prioritization of projects in situations involving different investment opportunities. However, when there is a high level of uncertainty and managerial flexibility, traditional valuation rules are not able to provide comprehensive indications for investment decisions. In this context, it is necessary to use additional tools that take into account the optimization process of managerial choices in an uncertain environment. The most adequate tool for this purpose is the Real Options Theory. With the real option methodology, asset values are estimated by discounted cash flows contingent on the exercise of optimizations. These optimizations are strategic alternatives intended to maximize shareholders value.

In the last decades, the evolution of financial models and computational techniques has significantly increased the use of the Real Options Theory in a variety of industries around the world. Myers (1977) was the first author to use the real options terminology based on the idea that real assets (projects) could be evaluated similarly to financial options. Brennan and Schwartz (1985) developed applications in options to abandon and/or temporary shut-down mining projects. Another relevant contribution was made by Bjerksund and Ekern (1990) in which a bundle of options and their interactions were evaluated in an analysis of an oil field.

The Real Options Theory has also been broadly applied in the electrical power sector (Herbelot (1992), Moreira, Rocha, and David (2004) and the real estate market Titman (1985), Williams (1991), Wang and Zhou (2006), Bulan, Mayer, and Somerville (2004). Choi, Kim, and Kim (2002)) use a valuation methodology for optional calling plan contracts similar to real options in the telephone industry.

For certain industries, an important and valuable real option is the capacity of switching outputs and/or inputs in the productive process. That is, if the demand or price of the products (or raw materials) fluctuates, management has the alternative to change to a more profitable product output mix or raw material input. Among the several works developed on switch option, one that is worth mentioning is Bastian-Pinto, Brandão, and Hahn (2009) in which a product output switch option in a Brazilian ethanol production plant is valued, more specifically the option to change the final product – sugar or ethanol – considering their prices as correlated MRMs. The authors estimate the projected cash flows of each product, which are dependent on the prices modeled but also on other variables such as operational leverage of the different production processes, and calculate the value of the option available to this industry of delivering the product that maximizes revenue at each future period. Using a bivariate mean reversion lattice approach, the authors conclude that this option significantly increases the NPV of a sugarcane based ethanol production plant. This further endorses the investment decision in more expensive sugarcane processing plants that can produce alternatively sugar and ethanol, instead of only one of those commodities, and have the flexibility to adjust output to market demands and price fluctuations.

This managerial flexibility is present in the steel industry as well and is an important strategy used to attenuate the significant variations on demand and prices of steel. Presently in this industry, depending on the intended use, different kinds of steel can be produced that vary in shape, purity level, and mechanical strength. Nevertheless, these options require investments in lamination assets to acquire the possibility of producing diversified steel products. Few studies were found relating steel sector and real options analysis and none valuing this managerial flexibility in the steel industry. Muharam (2011) values investment deferral, expansion and abandonment real options in the steel industry but does not consider product switch options in this sector.

It is important to note that the uncertainties present in projects are frequently modeled as Geometric Brownian Motion (GBM). But eventually these uncertainties may not follow the GBM. This is frequently the case when the variables modeled depend on an equilibrium level, as is the case with non-financial commodities (Brennan & Schwartz, 1985; Pindyck, 1999, 2001). Specifically, in the case of commodity prices or commodity-producing assets, it is common to assume that these prices or assets follow a Mean Reversion Model process — MRM (Schwartz, 1997; Schwartz & Smith, 2000). Nevertheless, there is no consensus as to which stochastic process is more adequate, and as Dixit and Pindyck (1994) suggest, the definition of the process depends as much on statistical as on theoretical considerations.

3. Steel industry overview

Steel production began before the Christian era. There are records indicating the Egyptians already had steel production knowledge in 900 B.C. and used it for weapons such as knives and swords. However, the production of steel on a large scale did not begin until the 19th century when technological evolution enabled the construction of bigger and more efficient furnaces.

Presently, steel is a very versatile product with a wide range of applications throughout the industry. Furthermore, the abundance of raw material for its production and its low production cost, gives steel a comparative advantage over other comparable materials, making it the most important alloy in modern society. According to the Brazilian Steel Institute (2009), the demand for steel corresponds to 90% of all metallic alloy consumed worldwide. The different uses of steel products include construction; naval, automotive and capital goods industries; household appliances; and packaging and pipes for diversified applications.

In spite of the many uses, the return on investments in the steel industry is subject to uncertainties. The main risk factor associated with the sector is its cyclical performance, which implies great variations in price and demand. As an example of this volatility, between 2000 and the end of 2009, the hot rolled steel price fluctuated between US $250.00 and US$1200.00 in the U.S. market (Fig. 1). This volatility effect is augmented by the highly leveraged financial structure of the industry

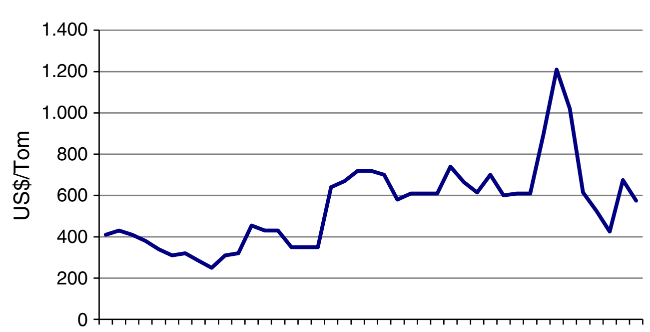

Fig. 1. Hot rolled steel price (US$/Ton) USA — Jan/2000 to Sept/2009. Bloomberg, 2009.