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The optimisation rule for investment in mining projects

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ABSTRACT

Investment in mining projects involves significant uncertainty. Project investment is usually high risk, irreversible and challenged by major economic factors. Mining commodity prices in particular always show greater volatility than any other primary products. The variation of these prices is critical in the investment decision of whether the project should go ahead, be abandoned or be delayed. This paper examines the impact of mineral price uncertainty on mining investment decisions using examples of projects in the Asia-Pacific region. Applying the mean reversion (MR) model, the commodity trigger value for investment decisions in each project is determined in the context of operational flexibilities. The findings indicate it is sometimes better to wait for a more suitable time to invest.

1. Introduction

Investment in the resource industry has three important characteristics. First, mining investment is partially or completely irreversible and the initial cost of investment is at least partially sunk. Second, investment in mining projects involves uncertainty over future rewards. Third, mining project investment has some leeway with regard to timing with the mining investor able to delay investment to obtain more information about future investment conditions. These three characteristics interact to determine the optimal decision rules of investors in mining investment decision making.

When investments are irreversible and the economic environment is volatile, the option value of maintaining flexibility is high. The ability to delay is a powerful component of the strategy of mining investment. The irreversibility of investment creates exposure to losses in the highly volatile commodity market. The research question addressed here, through empirical analysis using examples from Asia-Pacific mining investment projects, is: How can mining companies use the strategy of deferral to decide the optimal timing for investment when commodity prices are volatile?

Mining commodity prices always show greater volatility than those of any other primary products. As a result of these uncertainties, finding the critical price at which it is optimal to invest in a project, is crucial. To address the research question identified above, this research applies the mean reversion (MR) model, using the commodity trigger value to determine investment decisions.

The rest of the paper proceeds as follows. Section 2 discusses background studies on mining investment in the Asia-Pacific region and also presents the primary role of the mining industry in the Asian Century for certain mineral-exporting Asia-Pacific countries. Section 3 reviews previous literature on mineral price uncertainty. Section 4 introduces the model used to forecast mineral prices under the optimisation investment rule, applying timing with flexibility. Section 5 describes the data collection and presents the results. Section 6 concludes.

2. The mining industry and the Asian Century

The Asia-Pacific region is one of the major mineral producers and consumers in the world (APEC Business Advisory Council, 2014). In world terms, the region contains substantial natural resources, including a wide variety of non-fuel mineral reserves, such as copper, gold, nickel, tin and many more (O'Callaghan and Vivoda, 2010). In 2013, for instance, the APEC economies accounted for approximately 76% of world copper reserves, 65% of world zinc reserves, 87% of world lead reserves and 48% of world nickel reserves (APEC Business Advisory Council, 2014).[1]

The Asia-Pacific region covers a diverse landscape enriched with mineral resources and it is one of the most influential economic zones in

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[1] APEC has 21 members, which include Australia, Brunei Darussalam, Canada, Chile, the People's Republic of China, Hong Kong, Indonesia, Japan, the Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, the Philippines, Russia, Singapore, Chinese Taipei, Thailand, the USA and Vietnam. The resource sector is one of the most important industries in APEC economies and this region accounts for a substantial share of world mineral resources.

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Table 1
Contribution of mining to national economies in the Asia-Pacific region.
Source: International Council on Mining and Metals (2015) and Minerals Council of Australia (2014).

	Mining export contribution (2012)	Total export contribution (2012)	2012 production value (% of GDP)	2014 MCI Score
OECD members				
Australia	57.3%	69.0%	10.0%	89.36
Japan	3.7%	5.4%	0.0%	42.09
New Zealand	4.7%	9.5%	0.9%	40.76
East Asian economies				
China[a]	1.5%	2.9%	6.1%	39.54
Hong Kong SAR	14.9%	15.2%	0.0%	53.53
South Korea	2.7%	13.2%	0.1%	35.30
South-East Asian economies				
Indonesia	20.1%	40.7%	6.3%	78.46
Malaysia	2.6%	23.0%	0.6%	45.78
Philippines	6.3%	8.5%	2.5%	57.04
Singapore	1.8%	20.3%	0.0%	16.73
Thailand	5.2%	11.7%	0.7%	55.16
Pacific Island countries[b]				
Fiji	9.3%	34.1%	1.9%	71.94
Papua New Guinea	51.3%	68.5%	26.1%	88.54
Solomon Islands	15.5%	15.6%	10.1%	83.93
Tonga	7.5%	7.5%	0.0%	47.02
USA	7.7%	15.6%	0.8%	60.88

[a] Taiwan is included in China's MCI.
[b] These four Pacific Island countries are the major exporters of mineral resources. The contributions of the mining industry to national economies in other Pacific island countries, such as the Marshall Islands, Samoa, Timor-Leste and Vanuatu, only comprise zero to 20% of their economies. The table, therefore, only shows those countries in which the mining industry is the major source of income that sustains national economic growth.

the world. Some advanced economies in this region, Australia in particular, are significantly affected by the Asian economy as a result of the region's growing demand for commodities. The mining industry can generate 60–90% of a country's foreign direct investment (FDI), 30–60% of total exports, 3–20% of total government revenues, 3–10% of total national income and 1–2% of total employment (International Council on Mining and Metals, 2015). In 2014, the Mining Contribution Index (MCI) (see Table 1) shows that a majority of the Asia-Pacific countries are dependent on the mineral resource industry as a major source of revenue to sustain their national economies.

In 2011, the Asia-Pacific region was regarded as being the strongest region in the world in terms of total project loan financing for the mining industry. For example, in Australia the total project loan finance figures for 2011 were US$23.4 billion, the second highest total project loan in the world after India (Austrade, 2012). The increased demand for total project finance loans in the Asia-Pacific region can be attributed to the strong economic development in this region, particularly the strong demand for mineral resources in China and India.

3. Literature review

Economic viability in today's mining industry is highly dependent on sound company planning and management. A key decision support system, which mining firms can successfully apply to resolve their investment planning and management problems, is optimisation. Optimisation techniques include ore-body or reserve estimation, the design of optimal pits, optimal production planning, the determination of optimal mine operation layouts, the development of machinery maintenance and replacement policies, the implementation of an efficient mine site redevelopment programme, determining the best choice of machinery (e.g. trucks and loaders for mining operations) and the design and efficient operation of matters related to transportation and the logistics network to support mining operations (Caccetta, 2010, p. 547).

The use of optimisation decision support models in large-scale mining projects has been studied extensively, in the copper resource sector by Mondschein and Schilkrut (1997), Caldentey and Mondschein (2003) and Caldentey et al. (2007). Epstein et al. (1999) examines techniques used in the renewable forestry industry, while their use in the oil industry is examined by Baker and Lasdon (1985), Dyer et al. (1990) and Gibson and Schwartz (1990).

The advantage of using these optimisation decision techniques is that mining firms are able to evaluate their investment projects by choosing those that have short-term and long-term profitability. Caldentey et al. (2007) point out that most of these models use state variables, such as commodity market prices and mineral demand, as independent variables to determine mining firms' investment decisions. Within optimisation modelling, real option valuation (ROV) is one of the most powerful financial techniques, assessing all information by incorporating timing flexibility to evaluate large-scale mining projects.

When dealing with uncertainty in the real options model, Schwartz and Smith (2000) show the significant role the stochastic model of commodity prices plays in evaluating mining project investment. Price variables in a stochastic model evolve in either discrete or continuous time periods in an unpredictable way. Stochastic price behaviour can be estimated using either a geometric Brownian motion (GBM) (Brennan and Schwartz, 1985; McDonald and Siegel, 1986), especially in the short term, or using a mean reversion (MR) model (Ozorio et al., 2013) in the long term. Monte Carlo simulation (MCS) is a stochastic approach used with either GBM or MR in forecasting mineral prices.

In early studies using stochastic models in relation to price risks, researchers tended to assume that commodity prices followed a "random walk" (described by GBM).[2] GBM is a process that does not follow any simple deterministic rule, such as "a commodity price will increase by *X* percent every year". The path of stock prices in the share market is often used as an example of a GBM process because the path is purely random and cannot be predicted. When applying the GBM model, it is expected that increases in commodity prices in one time period have persistence in lifting the starting level for all future forecasted commodity prices.

Although GBM is one of the common stochastic models for mineral price modelling, several studies have also examined using the MR price model in evaluating commodity price risks in the mining industry (e.g. Laughton and Jacoby, 1993; Cortazar and Schwartz, 1994; Dixit and Pindyck, 1994; Smith and Mccardle, 1999). In the long term, for most commodity prices, mean reversion is expected in prices to reflect underlying economic determinants of supply and demand. However, there is also uncertainty about the market commodity price equilibrium to which the commodity price reverts when applying the mean-reverting price model.

MCS is an approach to forecast commodity prices when commodity markets are highly volatile and uncertain. MCS is applied to valuing options through finite difference and binomial lattices models that generate forecast prices using assumptions about the underlying stochastic process, such as GBM or MR. The main applications of this method are risk analysis, risk quantification, sensitivity analysis and predictions, which enable mining investors to capture the impact of the uncertain variables that could most substantially affect their investment decisions.

[2] The GBM model was first used in the Black–Scholes (B–S) option pricing formula (Black and Scholes, 1973) for evaluating stock price uncertainty.