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ECONOMICS OF MINE PLANNING

AND EQUIPMENT SELECTION - PART 2

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This newsletter is a continuation of RPMGlobal Perspectives Issue 113 written by Ian Runge, founder of Runge Limited, on the fundamental economics of mining decisions. In this final part he continues the example of why "optimum" production rates for new mine developments derived from simple discounted cash flow analysis may be wrong ... i.e., too high. He also joins the contemporary debate on renewable and non-renewable resources from an economic perspective and poses the question: If you manufacture steel (for example) by recycling do you hold some moral high ground over someone who makes steel out of "non-renewable" iron ore; or if you generate electricity from non-renewable coal or uranium are you in a morally less-defensible position than someone who generates his electricity from, for example, solar, the wind, or tides?

Marginal Cost of Capital

In the last article (RPMGlobal Perspectives Issue 113) the argument was put that the production rate we typically consider "optimum" for the start-up of a new mine is commonly too high when assessed from a simple discounted cash flow perspective. The reason, examined in that article, was due to the declining

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marginal revenue effect. This next section looks further at the issue, and suggests that even considering marginal revenue effects the "optimum" production rate for the start-up of a new mine may still be too high. In this case, the issue has to do with the marginal cost of capital. In the calculations of marginal and average costs of production described up to this point, discounting to account for the capital investment has used the weighted average cost of capital. This term is the give-away. "Optimization" of anything has to be based on marginal costs, not average costs, and this applies to capital like anything else.

There are two components of this marginal cost of capital calculation that are high-lighted here: a risk element, and a size element.

Marginal Cost of Capital from a Risk Perspective

The prime element of the weighted average cost of capital for any company is the risk characteristics of its existing business. The risk characteristics of any new mine may be substantially different to the risk characteristics of a mining company's portfolio of existing mines. Risk associated with new mines will be higher at least until the mine is in full production.

Once a mine is in operation and its risk characteristics are understood with greater certainty then the cost of capital notionally applicable to the new mine will reduce. However, this is something that occurs only after the mine is in operation, not prior to commitment. The cost of capital that has to enter the equation at the time of the commitment decision is the cost then, not he expected cost after all the uncertainty has been resolved.

Of course, every effort is usually made in the feasibility study to address known risk elements, but some of these are un-knowable until the mine commences operation. Market demand is one of these elements –potential customers might say they will buy your product, and perhaps even provide a "letter of intent," but it is in their best interest to encourage greater supply to the market, so this intent cannot necessarily be relied upon. No amount of assessment prior to and during the feasibility study will necessarily reduce the uncertainty associated with this sort of input. Thus the risk, and with it, the marginal cost of capital for a new mine at the time of commitment is almost certainly higher than the weighted average cost of capital for the company itself.

Does the size of the company make any difference? A statement commonly heard is that such-and-such company (a large mining company) can develop projects that a small company cannot develop because they have a lower cost of capital. From this "risk" perspective this isn't necessarily true. A large company with a low weighted average cost of capital can still have a high marginal cost of capital if the new mine involves geographical locations or application of technology that they are unfamiliar with. A smaller enterprise with recognized expertise in the geographical area or recognized expertise in the technology can still have a lower marginal cost of capital even while having a higher average cost of capital.

Marginal Cost of Capital from a Size-of-Investment Perspective

This second component of the "marginal cost of capital" involves the size of the investment in relation to the size of the company. This is where larger companies frequently do have a competitive advantage over smaller enterprises.

In Figure 1 (also referenced in the previous article) the curves for all production rate scenarios were prepared using the [weighted average] cost of capital. This assumes that the extra investment necessary for a mine developed at the 48 Mtpa annual production rate can be sourced at the same cost as the smaller investment for a much smaller 16 Mtpa mine. If the size of the investment is small compared to the size of the company then this increase in funding cost may indeed be small. But for most companies as the amount of funding increases so does its cost. The cost of the extra funding (the marginal cost of capital) needed to finance the mine development at the higher production rate might make higher production scenarios uneconomic.

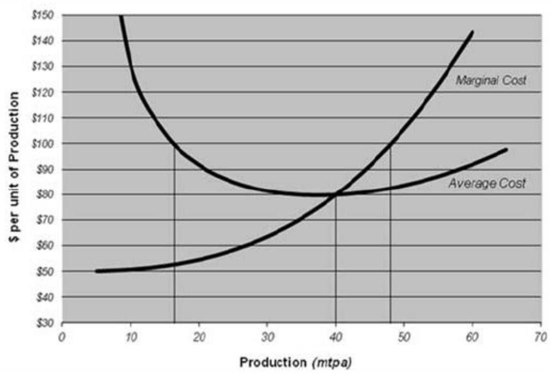

Figure 1: Average and Marginal Costs

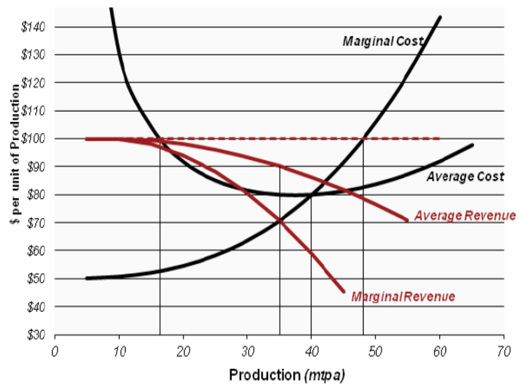

Figure 2: Impact of Declining Marginal Revenue on Optimum Production Rate

Figure 2 shows the impact of these two effects. The impact of these two "Cost of Capital" effects raises the average and marginal costs. The optimum production rate for the start-up of the mine is again where the marginal revenue line intersects the marginal cost line – in this case resulting in an optimum production rate of 31 Mtpa –a significant reduction from the 48 Mtpa rate that was the original rate from the simple "optimization" study that did not consider these effects.

The risk issues which partially give rise to the higher marginal costs of capital will often resolve themselves once the mine is in production. Thus, although the marginal cost of capital effect constrains initial production rates, just like the marginal revenue effect, over time the economic forces again favor expansion.

Bad Guys in a Commodity-Constrained World

This final part of the article looks at the economics of mining and exploitation of non-renewable resources. It poses the question: If you mine and burn coal to make electricity are you in a less-defensible moral position than someone who generates electricity from solar or wind? Are you unfairly exploiting the world's resources to the detriment of future generations?

Whilst this notion is often thought to be quite a contemporary one, it has actually been around for some time. The earliest scholarly mention of it can probably be attributed to William Stanley Jevons, a very respected English 1865 titled "The Coal Question." (Jevons, 1865) In the paper Jevons explored the implications of Britain's reliance on coal, and, given that coal was a finite, non-renewable energy resource, raised the question of sustainability. His central thesis was that the UK's supremacy over global affairs was transitory, and when the coal ran out so too would the British standard of living. He advocated constraint. Suffice it to say that Britain did not follow his recommendations. And while the UK's supremacy over global affairs was transitory, this undoubtedly was due to the rise of the American economy and to the impact of two world wars rather than to the run-down in coal production.

Economics of Reserve Estimation

This final part of the article looks at the economics of mining and exploitation of non-renewable resources. It poses the question: If you mine and burn coal to make electricity are you in a less-defensible moral position than someone who generates electricity from solar or wind? Are you unfairly exploiting the world's resources to the detriment of future generations?

It is undeniable that the earth's natural resources are finite, and if used continuously they will eventually run out. The world's reserves of copper, for example, equate to about 35 years of mining at current production rates, suggesting that this day of reckoning is not too far into the future. Most of the important mineral commodities used in the world have a similar limited future from this perspective, with some precious metals such as silver, for example, having reserves of less than 15 years at current production rates. This is clearly a source of concern to many, until we recognize that the same trends have existed since records started to be kept. Table 1 (page 4) shows the reserves of four important minerals in 1950 and 1980, compared to the production during the same period. (after Repetto, 1987)

Thus, from a 1950s perspective even though production in the ensuing 30 years exceeded, or nearly exceeded, the reserves available at that time, the reserves at the conclusion of the period far outweighed the reserves at the start. Indeed this trend applies for most commodities not just in total terms, but also in "years of production" terms. This is indeed comforting, but is it a trend we can rely on? If so, how far into the future can we rely upon it?

Mineral	Reserves 1950	Production 1950 – 1980	Reserves 1980
Aluminium	1,400	1,346	5,200
Copper	100	156	494
Iron	19,000	11,040	93,466
Lead	40	85	127

Table 1: World Reserves and Cumulative Production of Selected Minerals (millions of tonnes of metal content)

There are several reasons why history has proved Jevons concerns unjustified. The reasons also apply today for coal, oil, gas, and any other commodity. They involve the economics of reserve estimation, how effectively commodities are used in society, and the changes in technology that make some commodity that is important today far less important tomorrow. This article addresses just the economics of finding and delineating reserves, supported by the empirical evidence from history.

The reason this trend exists, and why it can be relied upon, comes down to simple economics. Exploring for and proving up reserves is costly. It is uneconomic to prove up reserves too far into the future, because the return from exploiting them only materializes when they are mined. The world would certainly take comfort in the knowledge that oil reserves, for example, are good for 60 or more years into the future, but what company can justify spending even $5 per barrel to prove up more oil now, in the knowledge that the oil won't be exploited until 2070 or later? It is just uneconomical.

How far into the future reserves are known is largely a function of how costly it is to prove up the reserves as a proportion of the costs of extraction. Silver has limited reserves (in comparison to annual production rates) because orebody delineation is a relatively high cost in typical silver deposits. In contrast, the delineation cost for most coal deposits, for example, is relatively low – accounting for the current "healthy" reserve position for coal at more than 100 years at current production rates. As the cost of proving up reserves increases in proportion to the total production cost, the reserve position in terms of "years into the future" will decline, but this says nothing about the total size of reserve or annual production rate.

A second concern commonly expressed involves supply and demand. In a market economy if there is a shortage of any commodity, the price will rise until supply matches demand. At this point the economics will favor additional exploration and deployment of technologies to exploit deposits hitherto considered uneconomic. There is no doubt that this has been an important factor in spurring new mining technologies throughout history.

However, it suggests that the world can rely on such an economic trend only at the cost of an ever-increasing real price of the scarce commodity. Much of the anxiety in the world today concerning oil rests on this assumption. Supply and demand fluctuations are important economic triggers to spur new technology.

A number of economic studies have considered this issue. Baumol and Blackman (1993), for example, quote several studies that found long term real prices static for the majority of mineral commodities over time. Even energy commodities such as coal, natural gas, and oil, though experiencing substantial fluctuations, show negligible upward trend in real (inflation-adjusted) price. "The price history of nonfuel minerals is even more striking. Some, like iron, have experienced a very slow rise over the last 100 years or so. The price of others, like lead, have remained stable. And for some, including aluminium and magnesium, real prices today are far lower than they were seventy years ago. The prices of about half of the mineral resources investigated actually fell after correction for inflation."

If reserves of important mineral commodities were indeed likely to be exhausted in 15 years, or even 30 years, then all of us, not just environmental activists, would see cause for alarm. However, the trends from at least 150 years show constant or reducing real costs of production and increasing reserves even with substantial and continual annual increases in production. This trend provides high confidence that future demand for these commodities can be met.

Let solar electricity generation compete. Let wind electricity generation compete. Let re-cycling compete. A level economic playing field for all technologies, including the extraction of non-renewable resources, is the best guarantee that these resources will be responsibly exploited. But let us not concede any advantage – moral or otherwise – to these competitors based only on the notion that the products we make are subject ultimately to exhaustion.

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