Cyest

CASE STUDY

Enterprise Optimisation

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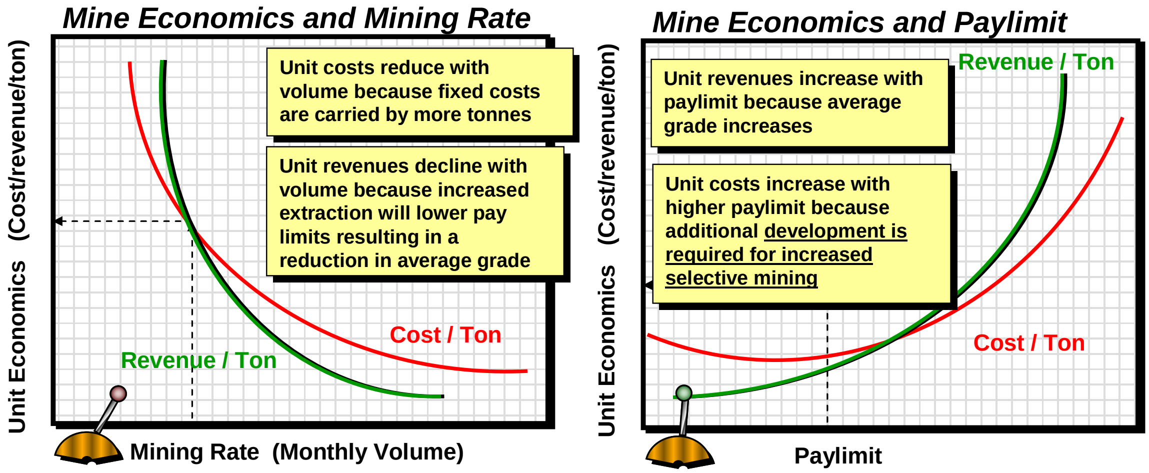
Optimisation entails the allocation or configuration of resources, that are within the control of management, to maximise (or minimise) a specific objective function. There is an optimal configuration of controllable variables (e.g. mining rate, cut-off grade, capital expenditure, capacity, ore mix etc) for a given set of external uncontrollable variables (e.g. geology, external market conditions, commodity prices etc). Optimisation requires a precise understanding of how changes in one (or more) of these variables or drivers will impact a single outcome or desired metric.

Optimisation generally implies a trade-off; there are often two (or more) opposing effects or consequences of changing any two variables. Thus, in mining for example, mine planners are often faced with contradictory objectives. Typically, planning implies optimisation even if it is not explicitly understood, as the planners have to make trade-offs in their planning process.

Typically, planning will attempt to balance maximum extraction of the resource with maximum value from its exploitation. These two objectives often work counter to one another as full extraction is invariably achieved with a low margin and long life, whilst value maximisation is generally focused on larger margins and a somewhat shortened life of the operation.

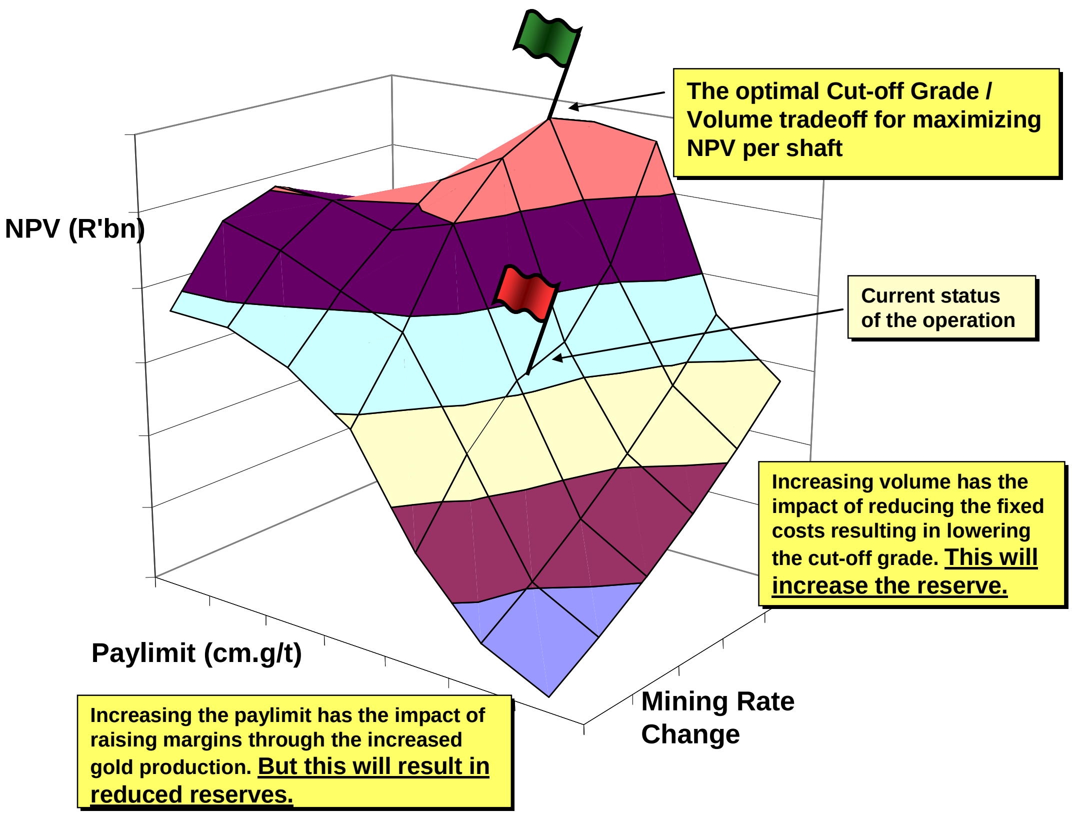
Figure 1 below demonstrates the typical trade-off between volume and pay limit (or cut-off grade). If management use the volume lever then as volume increases the unit cost of production should typically reduce through the leveraging of fixed costs. This in turn results in one being able to mine at a lower pay limit and therefore yielding a lower average revenue per tonne mined. Conversely, management can make an explicit decision to mine at a higher pay limit. This will increase the average revenue per tonne mined, but significant additional development is required to open up more areas so as to allow for more selectivity in order to achieve this higher pay limit.

Figure 1: *An Example of the Volume versus Pay limit Trade-off*



The only way to reasonably depict this trade-off is through what is termed the 'Hill of Value' (Hall 2003). This economic surface in *Figure 2* below, depicts the pay limit on one axis, the volume on the second axis, and, in this instance, shaft NPV (the objective function) on the vertical axis. Each combination of pay limit and volume is a unique scenario generated in a detailed economic model and takes all constraints, capex and costs into consideration to mine at that specific configuration. This 'Hill of Value' depicts the path to potential increased value for the shaft. Detailed geological and production planning – for example in CADSmine^{tm} – will still be required to confirm what is practically achievable.

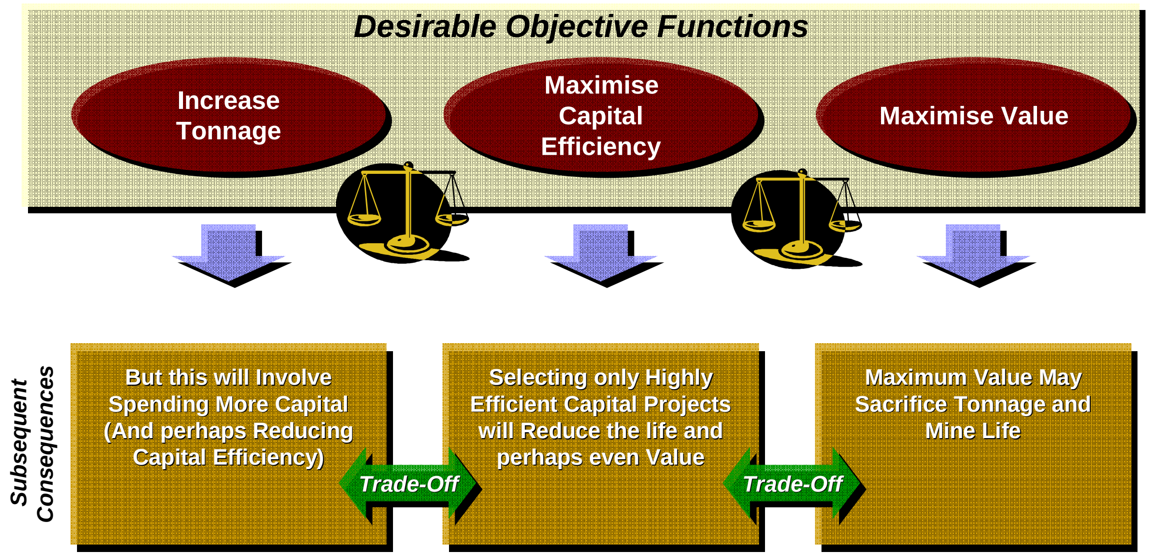
Figure 2: *A 'Hill of Value' for the Volume versus Pay limit Trade-off for a specific set of assumptions*



The Executives 'Dilemma'

The additional challenge that executives face in the mining industry is that the objective function in itself is a trade-off. Depending on where in its life the mine is, what the prevailing market conditions are and what shareholders are expecting, the objective function may vary. A strategy that yields the greatest NPV for the life of mine may not be viable under tough economic conditions where analysts and shareholders are still expecting short-term profitability which requires possibly mining at a higher pay limit at the expense of long term value. Capital yield criteria may omit projects that could potentially yield significant value for the operation.

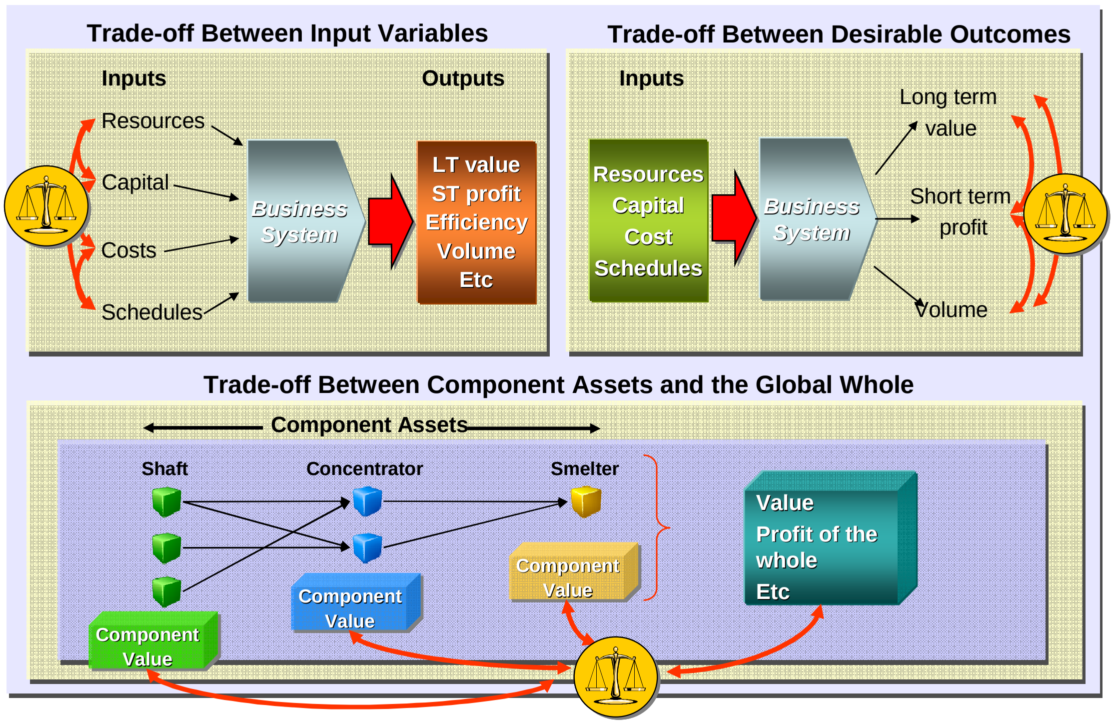
Figure 3: *Mining Executive Dilemma*



This challenge goes one step further in that maximising the value of each individual component of the business may not yield the maximum value for the group. For example maximising the value of each individual shaft, versus maximising the value from the concentrators, versus maximum value from the smelters, may not yield the maximum group value due to the individual component characteristics, downstream constraints and non-linear recovery grade relationships.

The maximum group value may require some shafts to plan below maximum capacity and therefore not maximise value. Rather, they may be required to route their material to lower recovery concentrators so as to yield more value from a high grade shaft. Therefore sub optimal individual components of the business may be required to maximise the whole businesses value. *Figure 4* below indicates the complete challenge faced between trade-offs on inputs, desirable outcomes (objective function) and between components in the business.

Figure 4: *The Three levels of Trade-off*



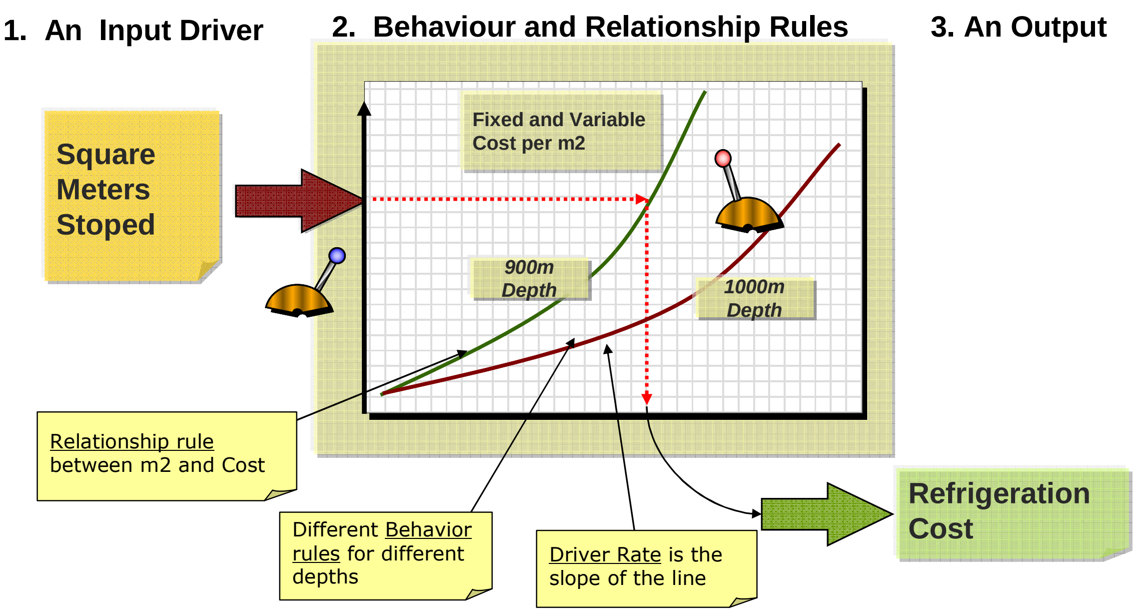
Generally to be able to perform a credible enterprise optimisation, an economic model with the appropriate level of detail would be required.

What is Economic Modelling?

An economic model is a mathematical representation of the real world. In the mining context it is an enumeration of the complete business, operation or shaft and integrates all production, labour and financial metrics into a holistic representation. The model also includes all the rules and relationships around constraints such as hoisting, tramming, ventilation and cooling for example.

A model consists of three fundamentals, namely an input driver, a behaviour or relationship rule and an output. The example below in *Figure 5* is a very simplified example to explain the concept for refrigeration cost. The input driver is "square metres stoped" at a given depth, the relationship rule is a cost curve depending on depth due to virgin rock temperature (VRT), and the output is the refrigeration cost per square metre for that depth.

Figure 5*: A model consists of three things*



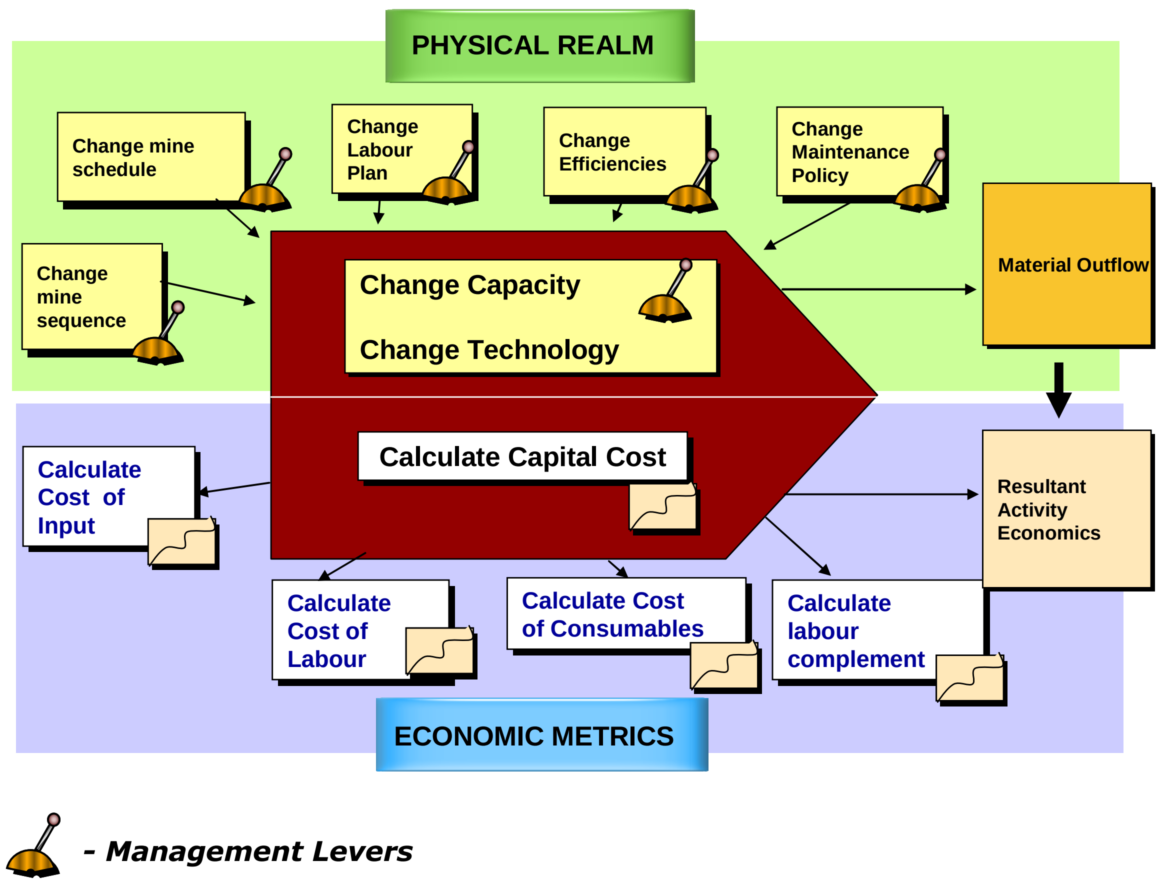
In this way an economic model of a mine is built up of thousands of such relationships. Some are empirical relationships provided by the engineers, others are relationships contained within the basic mining equations (BME) and some are derived from historical data mining.

Therefore, a representative economic model can generate all the operating costs, full labour complement and financial metrics for a given production schedule, and at the same time, flag any constraint breaches around hoisting, tramming, ventilation and cooling for example.

In some instances, the economic models built have incorporated all strategic planning polygons and the associated grade tonnage curves. This allows different production strategies to be quickly tested without the need for detailed mine planning. The chosen strategy can then be planned in detail in the general mining planning system to verify that it is achievable.

It is important to understand that modelling and forecasting are different concepts. Forecasting is about taking a given output such as stores cost and forecasting it into the future using a factor such as inflation. Modelling is about understanding what drives stores cost for a particular activity and modelling the relationship between that cost and its driver. Therefore costs can only be adjusted by understanding the levers management have under their control as represented in *Figure 6* below.

Figure 6: *Economic Model and Management Levers*



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<u>Platforms for Economic Modelling</u>

An appropriate modelling platform is required to be able to build an economic modelling.

Such analysis and modelling has generally been done in Microsoft Excel^{tm}, as this is a very cost effective modelling environment. However, the shortcomings of an Excel model are numerous, namely -\

- They are generally built for a one-off answer and as such are not easily usable over an extended period of time
- It is very difficult for someone not familiar with the structure of a spreadsheet model to run their own scenarios. This is an inherent shortcoming of all models where formulas are not transparent to the user and the structure is very much dependant on how the model evolved i.e. as the project develops the requirements of the model change resulting in continual adjustment of the model that makes it cumbersome eventually.
- Once built they are very difficult to change due to the restrictions associated with rows and columns.
- They are very difficult to audit.
- They have severe restrictions in terms of size / scale, and hence will not easily manage high levels of detail with the large volumes of associated data.

These and other inherent shortcoming of spreadsheet modelling has resulted in Cyest investigating alternative modelling platforms and therefore making a decision to develop in house a more powerful object orientated modelling platform called ***Carbon***. For more information refer to the separate brochure on ***Carbon***.

Practical Examples of Enterprise Optimisation

a) Optimising the Production Sequence and Schedule
b) Optimising the Pay limit versus Volume for each Shaft
c) Half Level Optimisation
d) Life of Mine Economics
e) Forecasting and Budgeting
f) Mine to Mill Optimisation

Contact Details

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