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Diamond deposit valuations using size frequency distributions and price modelling

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Introduction

Determining the overall $/ct value of a diamond deposit is critical for the economic evaluation of a target. The other value factor being the ct/t grade. For exploration, an early decision to abandon or proceed with development of an ore body allows capital resources to be more effectively used.

Bulk samples are an early evaluation activity and conventionally it is considered that about 5,000 - 8000 carats are necessary to make a 90% confident estimate of a $/ct value. It is the wide difference in price between boart ($0.04 for a 0.1 ct) and a top-quality gem ($100,000 for a 10 ct white sawable) that has resulted in the large sample size requirement and the development of a 'trumpet curve' that relates price uncertainty to carat volume assuming a typical rough production profile. Statistically this approach is sound where there is no relationship between the diamond prices across sizes, however there is both an inter-relationship between sizes (size frequency distribution) and a relationship between average diamond prices across sizes, so a different statistical approach is merited. By combining these two relationships the overall $/ct value can be modelled allowing sampling of a significantly smaller carat volume to achieve the same price uncertainty as indicated by an 8,000 ct sample.

Price-size profiles

Attempts have been made in the past to extrapolate quality profiles from small sizes to larger sizes. These studies have tended to use the broad categories of gem, near-gem and industrial, based on colour, clarity and shape. The shortcoming of this approach is these definitions are not well defined and don't scale between sizes. To avoid these subjective classifications, a better approach is to use the value of individual stones. Valuing rough diamonds is also subjective and depends on who and when they were valued, however some consistency can be assumed if the valuation is performed within an organisation having an established valuation protocol. For this study data from Rio Tinto have been used, consequently only primary deposits have been examined. The objective was to establish if there is a common relationship between $/ct price and diamond size for deposits.

Figure 1 shows the log-log relationship between the average $/ct and size for the several deposits. Their form shows two distinct regions with an inflection at around 0.7 ct (3 grain), where for sizes below the transition weight there is a 'curved' relationship while above it the relationship is linear except in the instance of Diavik. This anomalous relationship is on account of two dominant diamond populations.

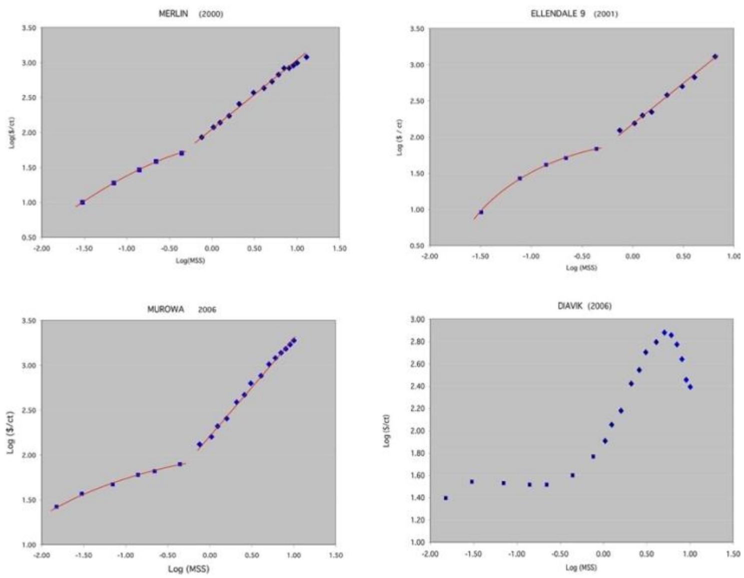

Figure 1: Plots of the value of each size fraction as a function of mean stone size (MSS) of each stone fraction show similarities except in the case of Diavik.

Normalising the prices to the 3-gr size produces the plot in Figure 2, from which it can be noted that the gradient is near 1.0 for three deposits. The implication from this linear relationship is if a $/ct value can be assigned to a 3-gr size then it is possible to estimate the $/ct value for sizes as large as 10 carats. Applying this approach to the Argyle deposit showed that the actual average value of 'specials' (stones above 10.8 cts) differed from the price predicted using the linear gradient model by a mere 10%, providing good validation of the method.

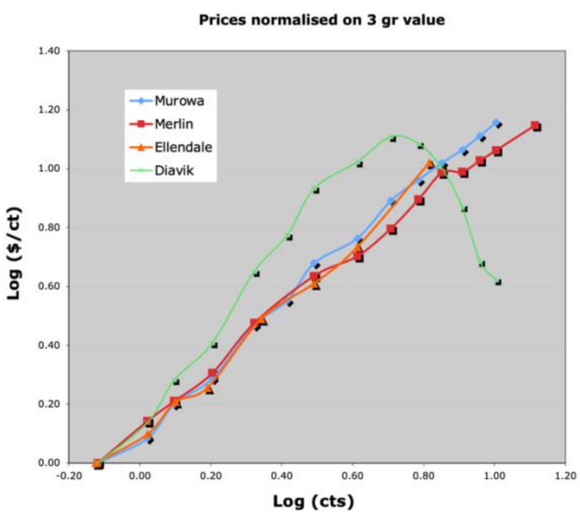

Figure 2: Normalising the values in Figure 1 to the 3-grainer value produces consistent gradients except for the anomalous Diavik deposit.

For sizes below the 3-gr threshold, the relationship is linear on a log-log scale in some instances, and in other instances it is more linear if the $/ct is un-operated (i.e. not logged). Between the different deposits examined there was no consistency of gradient for the < 3-gr range, (see figure 3). Depending on the sample size, smoothing between data points is appropriate, especially for example if the raw data presents a smaller size having a higher value than a larger size. In practice, the difference is minimal in modelled values using a linear relationship applied to either the $/ct value or its logarithmic form.

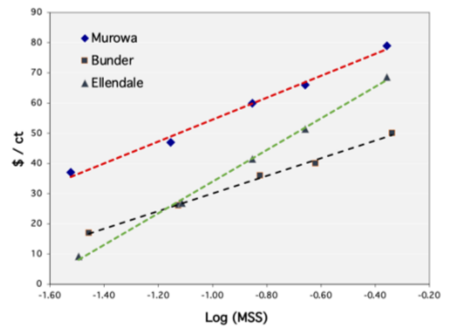

Figure 3: For the smaller sizes (+3 to +11 sieves), some deposits exhibit a linear relationship between the $/ct and log(MSS).

A regression can be used to simplify calculations bearing in mind that the value contribution of sizes below 3-gr is typically 35% of the overall value. Nevertheless the nature of the relationship is important in order to assign a value to the key 3-gr size used for extrapolations to the larger sizes that typically represent over half a deposit's value. The quantity of stones in these smaller sizes is significantly larger than the carater sizes, so the error in the valuations of the smaller sizes is lower.

Valuation Errors

The confidence error of an average $/ct value ('P') for a particular size class depends on the distribution of qualities within the class for a deposit's population. The standard deviation of stone values within each size class for three Rio Tinto mines was found to be very similar to the average value for that class. This relationship allows a standard deviation error to be assigned to an average $/ct value (P) derived from a quantity of n stones of $P/\sqrt{n}$.

Size frequency distributions

The other key component necessary to model the overall $/ct value of a deposit is the size frequency distribution (SFD) with which the price-size profile can be combined. Generating SFDs for diamond populations is well recognised as they belong to the log-normal family of curves. Such distributions plot as a quadratic curve on a log-log scale of weight vs quantity of stones per weight unit interval. Though in the context of modelling from bulk samples, the data is generally limited to the smaller sizes and extrapolating to the larger sizes is necessary and accompanied by uncertainties depending on the sample size. The extrapolation to larger sizes needs upper and lower uncertainty limits which can be derived by running Monte Carlo simulations of fitted quadratic regressions with each data point randomly varying in accordance with its standard deviation error. This error should be based on a Poisson distribution which can be reasonably approximated for $n>4$ by $\sqrt{n}$.

Conclusion

Determining the value P_{3gr} of a 3-gr class by extrapolating and interpolating average valuation data for any recovered sizes enables extrapolation to carater sizes. Combined with smoothed raw for the smaller (sieve) sizes and an SFD enables valuations for decision making using a mere few hundred carats rather than the conventional 8,000 cts. Consideration for the errors in both valuation and SFD data and a target value for an economic project would indicate whether an expanded sampling volume is needed.

References

Caers J., Rombouts L. 'Valuation of primary diamond deposits by extreme value statistics' *Economic Geology* (1996) Vol 91 No 5: 841-845

Davy, A.T., M.J. Rayner, and R.W. Platell. 'The Diamond Size Frequency and Size Quality Distributions in the Argyle AK1 Lamproites'. International Kimberlite Conference: Extended Abstracts (2017).

Chapman JG, Boxer GL 'Size distribution analyses for estimating diamond grade and value'. *Lithos* (2004) 76:369–375.