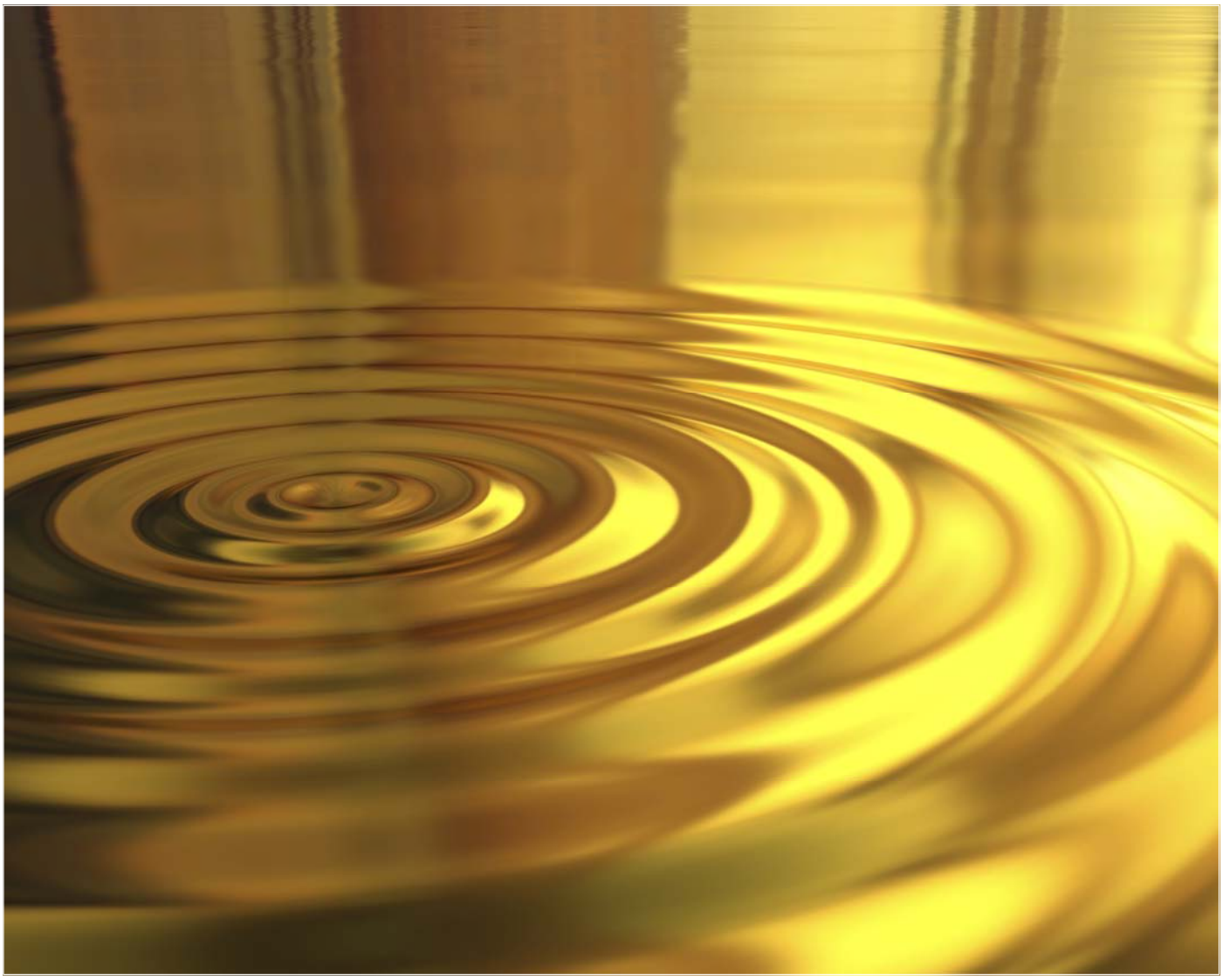
EDISON





# Mining overview: Unlocking the price to NPV discount

## A new world order

Mining sector report, November 2017

Published by Edison Investment Research

## Foreword

Equity investors are well aware of the returns achievable in mining when markets get behind an early-stage story. This can drive share prices quickly in often wildly different directions, depending on a range of criteria, ie the size and stage of resource, commodity type, listing country, etc. For the last few years Edison has published its annual mining sector report, which assesses how markets consider and potentially value these different criteria. The analysis is not simple and we attempt to normalise for anomalies (of which there are many in mining) to develop a suite of tools that investors can use to assess the plethora of different investment options out there.

Moving into developments, our report considers for the first time the discounts to NPV that markets are applying to projects at different stages. In conjunction with our discount rate analyses, these studies throw up interesting observations that can help companies and investors alike understand where there are opportunities for value creation, and where there are risks of value traps.

Our report concludes with our gold price outlook. Edison's post-QE approach of basing our forecasts on the total US monetary base is under pressure with the US Fed's plans to shrink its balance sheet. As a result, we have adopted a different approach in the short term, although investors should be aware of the headwinds facing the gold price.

So why is this report important to you?

- For listed companies this report serves as a basis for the deep analytics we can deploy in our award-winning equity research when valuing early-stage and development companies.
- For private companies the report serves as a basis for assessing funding options and potential market engagement where we can help with due diligence and/or valuation and IPO research.
- Edison's IR team works closely with our research analysts to ensure our client companies understand the most logical pools of capital to target and how these may evolve through time.
- For investors we are ultimately able to help you guide your investment decisions and support you through detailed market analysis and/or specific project enquiries.

Against a backdrop of increasing regulatory uncertainty owing to MiFID II, Edison's mining team is here to help all market participants and we look forward to talking through the report with you in the near future.

Ian McLelland
Global Head, Natural Resources

November 2017

# Unlocking the price to NPV discount

## A new world order

Metals & mining

16 November 2017

**"The Fed can change how things look, not how things are."**
**Jim Grant, financial analyst**

## Value perceptions shifting between markets

In this report, Edison has updated its in-situ values for resources delineated by junior exploration companies. In the case of gold, we observe increases in in-situ values for early-stage resources listed in Canada and Australia, but not London. By contrast, there is tangible evidence that the London market is ascribing value to blue-sky potential that is evident in neither Australia nor Canada, whereas in Australia size appears to be king. This we attribute to the London market having recently been starved of new mining investment opportunities, whereas Australian investors appear to be shifting to a more conservative investment approach after the tribulations of past cycles. In contrast to gold, 16 of the 17 other metals and minerals analysed by Edison display evidence of investors discounting blue-sky potential (cf seven in 2016), although for 10, it is likely to be value destroying for juniors to upgrade their resources from the indicated into the measured category. Otherwise, the equity markets appear to be discounting higher prices in the case of six commodities and undervaluing juniors in the case of five. Nevertheless, the overall environment is one of risk averseness, with 29 jurisdictions apparently un-investible for an average gold project (cf 22 last year) and the threshold grade for investibility in an otherwise average gold project rising from 1.66g/t to 1.82g/t.

## EV/NPV ratios correlated to discount rates

For the first time in this series of reports, Edison performed a price to project NPV analysis for a sample of 63 companies. The results correlate extremely closely to Edison's past analyses of companies at different stages of development in terms of variable discount rates. The 'average' project has a published NPV of US$433.1m, an average IRR of 43.2% and the average company valuation is 52.4% of NPV. However, the skewness of the distribution of valuations relative to project economics renders mean values of much less use in formulating valuations than modal values. In determining a company's valuation, we also prove that the most important tangible factor is its project grade, followed by its IRR, its jurisdiction and its size. However, all vary with time. In general though, investors appear to exhibit a preference for projects with a lower capital intensity – perhaps as a consequence of a lack of certainty over the size and direction of future metals' price movements.

## Gold price forecasts

Finally, Edison has updated its gold price forecasts. Historically, these have been derived with respect to their historical correlation with the total US monetary base, inflation and interest rates. However, in the wake of the Federal Reserve's plan to shrink its balance sheet by a third over the next five years and the breakdown in the relationship between the total US monetary base and inflation, we have now shifted our methodology to one that predicts the gold price within the context of future movements in US currency in circulation. This maintains continuity with past forecasts. Nevertheless, we continue to show the results of other predictive models for context.


**Analysts**

Charles Gibson +44(0)20 3077 5724
Tom Hayes +44 (0)20 3077 5725
mining@edisongroup.com

## Contents

# Executive summary

In past publications, Edison has derived differentiated values for measured, indicated and inferred gold resource ounces listed in London, Canada and Australia. This report updates these numbers and extends the methodology to other metals and minerals (provided overleaf). For the first time, Edison has also performed a price to project NPV analysis over a sample of 63 companies. The analysis covers gold, silver, uranium, copper and zinc juniors, and three types of study, namely preliminary economic assessments (PEAs), pre-feasibility studies (PFSs) and bankable feasibility studies (BFSs). The intention of the analysis was to investigate the relationship between four project variables (grade, IRR, size and jurisdiction) and the valuation of their host company. This analysis also served as a means to benchmark our market derived discount rates for companies at different stages of development. Finally, we have updated our gold price forecasts within the context of the commencement of the Federal Reserve's reduction of its balance sheet and increasing expectations of a return to positive real interest rates in the US.

## Gold

Results for gold explorers, including the variance in calculated values from Edison's previous report on the subject (Mining overview: Normalisation augers well for exploration, published in October 2016), are provided in the table below. Results for the whole suite of metals and minerals analysed are given in Exhibit 2 on page 5, overleaf.

**Exhibit 1: Global average value of in-situ explorers' gold resources, by listing, US$/oz**

| | July 2017 | | | | August 2016 | | | | Variance (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| London market | 17.88 | 10.27 | 7.33 | 10.34 | 86.74 | 28.39 | 10.51 | 31.17 | -79.4 | -63.8 | -30.3 | -66.8 |
| Canadian market | 47.49 | 6.92 | 11.64 | 15.68 | 87.52 | (8.46) | 6.00 | 12.81 | -45.7 | 181.8 | 94.0 | 22.4 |
| Australian market | 98.57 | 36.58 | 7.33 | 31.27 | 226.06 | 15.15 | 5.51 | 43.47 | -56.4 | 141.5 | 33.0 | -28.1 |
| Arithmetic mean | 54.65 | 17.92 | 8.77 | 19.10 | 133.44 | 11.69 | 7.34 | 29.15 | -59.0 | 53.3 | 19.5 | -34.5 |
| Geometric mean | 43.70 | 12.89 | 11.00 | 17.54 | 35.66 | 15.65 | 7.61 | 16.84 | 22.5 | -17.6 | 44.5 | 4.2 |

Source: Edison Investment Research

A number of features of the results are immediately apparent with respect to gold explorers:

- The increases in the values of relatively early-stage inferred and indicated ounces in both Canada and Australia at the expense of the value of measured ounces.
- Globally, the average value of an average ounce is little changed compared to that in August 2016, despite the fact that the gold price declined from US$1,320/oz to US$1,228/oz in the intervening time.
- That the average value of ounces quoted in the London market is lower than that observed in the other two markets for the first time since this series of analyses began.
- That valuations overall remain consistent with bear market conditions, generally (see Exhibits 17, 19, 110-112).

# In-situ valuation summary

## Exhibit 2: Selected metals' and minerals' in-situ values, costs of discovery, etc, 2017

| Resource multiple | AIM gold | Canada gold | Australia gold | Global gold (geo) | Global gold (arith) | Silver | Uranium | Iron ore | Copper | Nickel | PtE | Coal (thermal) | Coal (met.) | Potash (SOP) | (SOP Brine) | Potash (MOP) | Zinc | Vanadium | Tungsten | Lithium | Lithium (spodumene) | Graphite | Bauxite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured | 17.88 | 47.49 | 98.57 | 43.70 | 54.65 | 0.45 | 6.93 | 0.125 | -59.00 | 95.37 | -76.55 | -0.040 | | -3.16 | 4.47 | -0.84 | 185.94 | 205.49 | 1,251.59 | -198.89 | -206.47 | -30.31 | -9.44 |
| Indicated | 10.27 | 6.92 | 36.58 | 12.89 | 17.92 | 0.18 | -0.53 | 0.084 | 28.23 | 16.51 | 29.44 | 0.025 | | 1.12 | 0.36 | 0.25 | 14.27 | 56.40 | 100.87 | 92.33 | 140.86 | 20.51 | 11.32 |
| Inferred | 7.33 | 11.64 | 7.33 | 11.00 | 8.77 | 1.28 | 0.50 | 0.026 | 17.58 | 4.46 | 2.38 | 0.025 | | 0.27 | 0.36 | 0.11 | 11.13 | 21.37 | 108.47 | 33.43 | 49.14 | 1.29 | -0.21 |
| Total/Average | 10.34 | 15.68 | 31.27 | 17.54 | 19.10 | 0.56 | 0.32 | 0.057 | 14.35 | 16.44 | 2.78 | 0.017 | 0.017 | 0.51 | 0.58 | 0.05 | 36.90 | 54.40 | 162.90 | 39.16 | 75.95 | 4.02 | 1.09 |
| Spot price | 1228.7 | 1228.7 | 1228.7 | 1228.7 | 1228.7 | 16.10 | 20.79 | 72.23 | 6,238.00 | 10,250.00 | 972.00 | 85.00 | 120.00 | 800.00 | 800.00 | 218.00 | 2,871.00 | 20,947.50 | 24,750 | 11,200.00 | 11,200.00 | 1,750.00 | 50.00 |
| **Unit** | **$/oz** | **$/oz** | **$/oz** | **$/oz** | **$/oz** | **$/oz** | **$/lb** | **$/t** | **$/t** | **$/t** | **$/oz** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** |
| **Percentages of spot** | | | | | | | | | | | | | | | | | | | | | | | |
| Measured | 1.46% | 3.87% | 8.02% | 3.56% | 4.45% | 2.80% | 33.33% | 0.17% | -0.95% | 0.93% | -7.88% | -0.05% | 0.00% | -0.39% | 0.56% | -0.38% | 6.48% | 0.98% | 5.06% | -1.78% | -1.84% | -1.73% | -18.87% |
| Indicated | 0.84% | 0.56% | 2.98% | 1.05% | 1.46% | 1.09% | -2.53% | 0.12% | 0.45% | 0.16% | 3.03% | 0.03% | 0.00% | 0.14% | 0.04% | 0.12% | 0.50% | 0.27% | 0.41% | 0.82% | 1.26% | 1.17% | 22.63% |
| Inferred | 0.60% | 0.95% | 0.60% | 0.89% | 0.71% | 7.95% | 2.41% | 0.04% | 0.28% | 0.04% | 0.24% | 0.03% | 0.00% | 0.03% | 0.04% | 0.05% | 0.39% | 0.10% | 0.44% | 0.30% | 0.44% | 0.07% | -0.42% |
| Total/Average | 0.84% | 1.28% | 2.54% | 1.43% | 1.55% | 3.50% | 1.52% | 0.08% | 0.23% | 0.16% | 0.29% | 0.02% | 0.01% | 0.06% | 0.07% | 0.02% | 1.29% | 0.26% | 0.66% | 0.35% | 0.68% | 0.23% | 2.17% |
| **Costs of discovery** | | | | | | | | | | | | | | | | | | | | | | | |
| Measured | 36.82 | 36.82 | 36.82 | 36.82 | 36.82 | | 1.37 | | | | 4.18 | | | | | | | | | | | | |
| Indicated | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | | 0.92 | | | | 1.26 | | | | | | | | | | | | |
| Inferred | 7.16 | 7.16 | 7.16 | 7.16 | 7.16 | | 0.09 | | | | 0.9 | | | | | | | | | | | | |
| Total/Average | 8.81 | 8.81 | 8.81 | 8.81 | 8.81 | | 1.02 | | | | 0.9 | | | | | | | | | | | | |
| Percentages | **0.72%** | **0.72%** | **0.72%** | **0.72%** | **0.72%** | | **4.91%** | | | | **0.09%** | | | | | | | | | | | | |
| **Return on upgrade** | | | | | | | | | | | | | | | | | | | | | | | |
| Measured | -71.1 | 54.1 | 135.5 | 17.1 | 39.5 | | 1,556.7 | | | | -3,729.9 | | | | | | | | | | | | |
| Indicated | -12.2 | -241.4 | 775.8 | -43.4 | 174.1 | | -223.9 | | | | 7,417.2 | | | | | | | | | | | | |
| Inferred | 2.4 | 62.6 | 2.4 | 53.6 | 22.5 | | 457.5 | | | | 164.2 | | | | | | | | | | | | |
| **Number of companies** | 7 | 39 | 27 | 73 | 73 | 16 | 28 | 13 | 15 | 11 | 4 | 7 | 2 | 4 | 3 | 5 | 6 | 4 | 5 | 9 | 3 | 15 | 4 |

Source: Edison Investment Research. Note: Platinum equivalent (PtE) costs of discovery derived from Witwatersrand gold cost of discovery. August 2017.

## Exhibit 3: Selected metals' and minerals' in-situ values, costs of discovery, etc, 2016

| Resource multiple | AIM gold | Canada gold | Australia gold | Global gold (geo) | Global gold (arith) | Silver | Uranium | Iron ore | Copper | Nickel | PtE | Coal (thermal) | Coal (met.) | Potash (SOP) | (SOP Brine) | Potash (MOP) | Zinc | Vanadium | Tungsten | Lithium | Lithium (spodumene) | Graphite | Bauxite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Measured | 86.74 | 87.52 | 226.06 | 35.66 | 133.44 | (2.07) | 3.40 | (0.06) | 36.97 | 106.62 | (9.24) | 0.03 | 5.87 | (6.44) | (2.16) | (2.76) | (7.03) | 135.15 | 1,627.68 | 96.47 | | 36.10 | 1.78 |
| Indicated | 28.39 | (8.46) | 15.15 | 15.65 | 11.69 | 1.16 | (0.64) | 0.12 | 2.23 | 22.11 | 2.98 | 0.07 | 0.04 | 1.26 | 2.53 | 0.83 | 14.02 | (6.73) | 368.47 | 18.51 | 213.13 | 11.38 | (1.13) |
| Inferred | 10.51 | 6.00 | 5.51 | 7.61 | 7.34 | 0.13 | 0.28 | (0.00) | 16.59 | 5.87 | 2.98 | 0.01 | 0.01 | 0.30 | 0.45 | 0.11 | 10.85 | 9.64 | 89.59 | 23.17 | 29.30 | 2.01 | (0.04) |
| Total/Average | 31.17 | 12.81 | 43.47 | 16.84 | 29.15 | 0.59 | 0.15 | 0.03 | 15.94 | 19.43 | 2.31 | 0.01 | 0.10 | 0.54 | 1.24 | 0.02 | 9.45 | 18.01 | 189.60 | 25.72 | 124.91 | 6.42 | 0.39 |
| Spot price | 1,320.00 | 1,320.00 | 1,320.00 | 1,320.00 | 1,320.00 | 18.79 | 25.95 | 57.78 | 4,622.25 | 10,325.75 | 1,048.52 | 69.43 | 82.52 | 650.48 | 650.48 | 266.43 | 2,291.75 | 8,489.25 | 22,000.00 | 10,000.00 | 10,000.00 | 1,250.00 | 50.00 |
| **Unit** | **$/oz** | **$/oz** | **$/oz** | **$/oz** | **$/oz** | **$/oz** | **$/lb** | **$/t** | **$/t** | **$/t** | **$/oz** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** | **$/t** |
| **Percentages of spot** | | | | | | | | | | | | | | | | | | | | | | | |
| Measured | 6.57% | 6.63% | 17.13% | 2.70% | 10.11% | (11.01%) | 13.10% | (0.11%) | 0.80% | 1.03% | (0.88%) | 0.04% | 7.11% | (0.99%) | (0.33%) | (1.03%) | (0.31%) | 1.59% | 7.40% | 0.96% | 0.00% | 2.89% | 3.56% |
| Indicated | 2.15% | (0.64%) | 1.15% | 1.19% | 0.89% | 6.15% | (2.47%) | 0.21% | 0.05% | 0.21% | 0.28% | 0.09% | 0.05% | 0.19% | 0.39% | 0.31% | 0.61% | (0.08%) | 1.67% | 0.19% | 2.13% | 0.91% | (2.26%) |
| Inferred | 0.80% | 0.45% | 0.42% | 0.58% | 0.56% | 0.69% | 1.10% | (0.00%) | 0.36% | 0.06% | 0.28% | 0.01% | 0.02% | 0.05% | 0.07% | 0.04% | 0.47% | 0.11% | 0.41% | 0.23% | 0.29% | 0.16% | (0.07%) |
| Total/Average | 2.36% | 0.97% | 3.29% | 1.28% | 2.21% | 3.15% | 0.56% | 0.05% | 0.34% | 0.19% | 0.22% | 0.02% | 0.12% | 0.08% | 0.19% | 0.01% | 0.41% | 0.21% | 0.86% | 0.26% | 1.25% | 0.51% | 0.77% |
| **Costs of discovery** | | | | | | | | | | | | | | | | | | | | | | | |
| Measured | 36.82 | 36.82 | 36.82 | 36.82 | 36.82 | | 1.37 | | | | 4.18 | | | | | | | | | | | | |
| Indicated | 10.5 | 10.5 | 10.5 | 10.5 | 10.5 | | 0.92 | | | | 1.26 | | | | | | | | | | | | |
| Inferred | 7.16 | 7.16 | 7.16 | 7.16 | 7.16 | | 0.09 | | | | 0.9 | | | | | | | | | | | | |
| Total/Average | 8.81 | 8.81 | 8.81 | 8.81 | 8.81 | | 1.02 | | | | 0.9 | | | | | | | | | | | | |
| Percentages | **0.67%** | **0.67%** | **0.67%** | **0.67%** | **0.67%** | | **3.93%** | | | | **0.09%** | | | | | | | | | | | | |
| **Return on upgrade** | | | | | | | | | | | | | | | | | | | | | | | |
| Measured | 121.69 | 264.70 | 701.34 | (23.98) | 362.58 | | 797.88 | | | | (518.57) | | | | | | | | | | | | |
| Indicated | 435.29 | (533.01) | 188.41 | 140.74 | 30.23 | | (211.49) | | | | (100.00) | | | | | | | | | | | | |
| Inferred | 46.77 | (16.24) | (23.01) | 6.29 | 2.51 | | 215.73 | | | | 231.59 | | | | | | | | | | | | |
| **Number of companies** | 12 | 16 | 14 | 42 | 42 | 14 | 24 | 17 | 17 | 8 | 5 | 8 | 3 | 4 | 3 | 7 | 5 | 6 | 5 | 9 | 6 | 9 | 4 |

Source: Edison Investment Research. Note: Platinum equivalent (PtE) costs of discovery derived from Witwatersrand gold cost of discovery. August 2016.

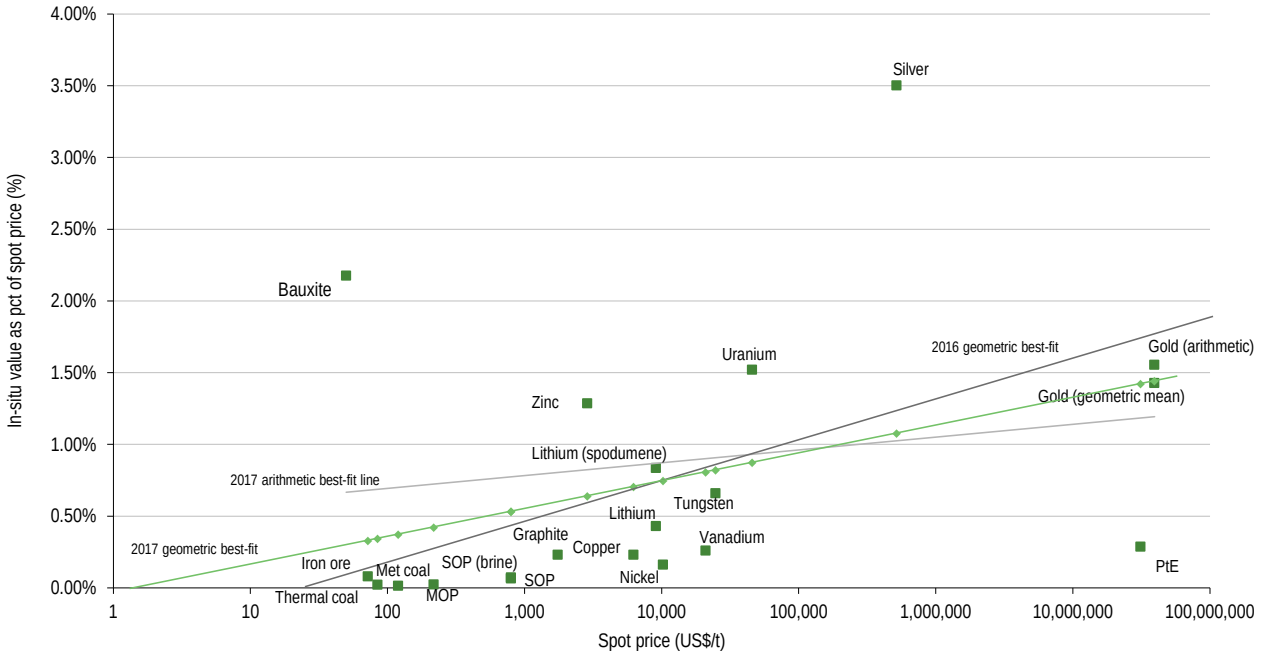
## Financial returns from exploration

The investment return from drilling an 'average' 1Moz gold resource is positive to varying degrees for gold assets listed in Australia and Canada, but not for those listed in London. However, there is tangible evidence that, for a non-average deposit, the London market is prepared to afford value for blue-sky potential, whereas the Canadian and Australian markets will not. By contrast, the Australian market will afford proportionately greater valuations the more resources are delineated.

Financial returns from PGM exploration appears to have similarly improved, compared to August 2016, however those from uranium have deteriorated, with declines in the implied value of inferred uranium resources, in particular.

Plotted relative to the market value of each of their commodities, in-situ resources are valued as follows.

**Exhibit 4: In-situ resource values vs spot prices, selected metals and minerals**




Source: Edison Investment Research

Note that the best fit line in 2017 is markedly more flat lying than the equivalent line in 2016, such that companies with deposits of metals or minerals with a spot price of US$1.43/t or more may now expect to be afforded an in-situ value for their resources, cf an equivalent price last year of US$18.82/t. Deposits that may now be afforded an in-situ value, but which were previously denied one, could therefore include such lower value minerals as limestone.

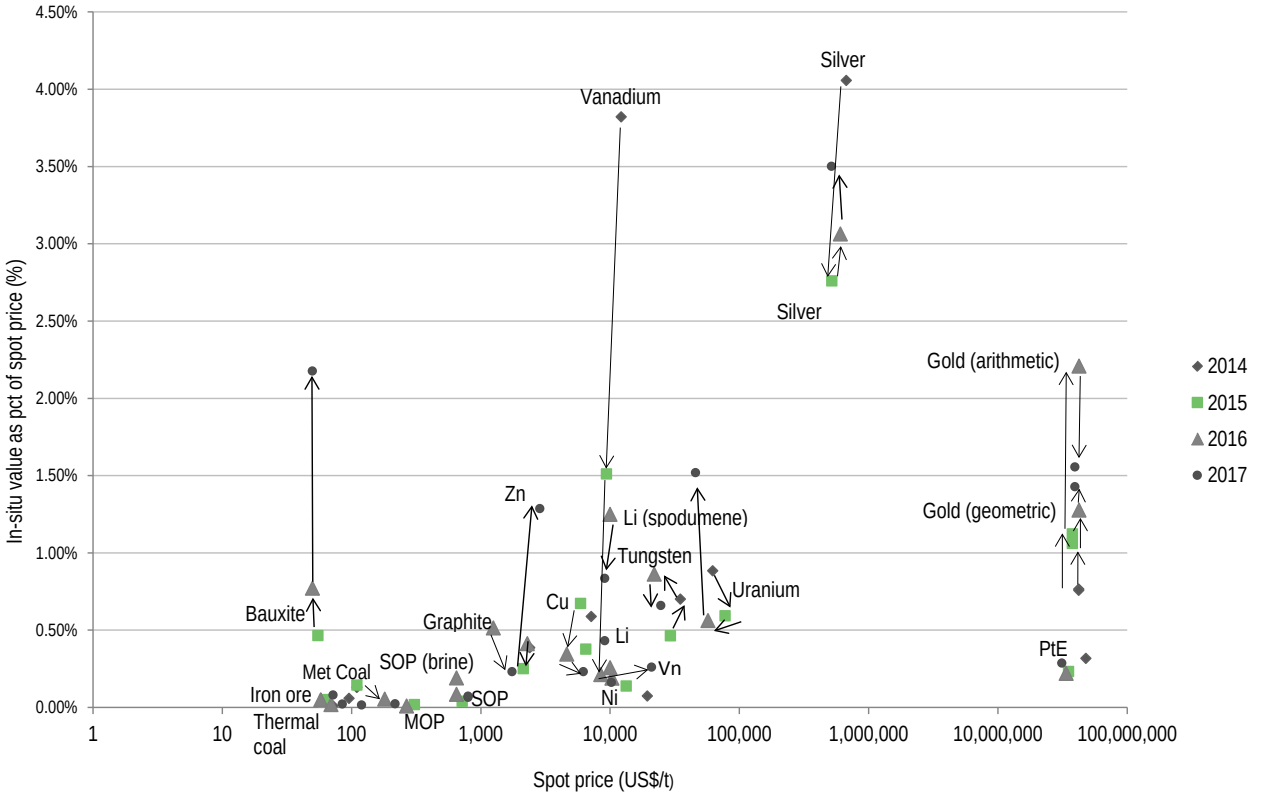
## Equity markets discounting future movements in commodity markets

Of the 17 distinct metals and minerals profiled (NB SOP appears twice as SOP and SOP (brine)) , the prices of seven (gold, uranium, silver, platinum, nickel, MOP and graphite) declined since Edison's last note on the subject (Mining overview: Normalisation augers well for exploration, published in October 2016). In the same timeframe, the prices of nine (iron ore, SOP, copper, zinc, tungsten, vanadium, lithium, metallurgical coal and thermal coal) have risen, while one (bauxite) is ostensibly unchanged (despite the fact that aluminium was one of the best performing metals over the course of the past 13 months – see Exhibit 15) .

Similarly, the in-situ values of eight metals and minerals (namely copper, nickel, metallurgical coal, SOP, SOP brines, tungsten, spodumene lithium and graphite) have declined since October 2016 in both nominal and percentage terms, while the in-situ values of 10 (gold, uranium, iron ore, platinum, thermal coal, MOP, zinc, vanadium, lithium and bauxite) have increased. However, not all of the metals and minerals that saw price increases also saw in-situ values increases and vice versa. Exceptions were:

- In-situ values declined in both nominal and percentage terms, despite prices rising, thereby implying either that the equity markets may be discounting future falls in their associated commodity prices or that equity markets are undervaluing junior exploration companies with such resources: copper, metallurgical coal, SOP, SOP brines, spodumene lithium and tungsten.
- In-situ values increased in both nominal and percentage terms, despite prices falling, thereby implying that the equity markets may be discounting future rises in their associated commodity prices or that equity markets are overvaluing junior exploration companies with such resources: gold, uranium, platinum, MOP and bauxite.

**Exhibit 5: In-situ resource values vs spot prices, selected metals and minerals, 2014-17**




Source: Edison Investment Research

## Discretion required to avoid 'over-exploring'

A number of metals and minerals exhibit a premium valuation for indicated resources. Whether or not this reflects that market's approach to the valuation of equities, it is strongly indicative of the fact that exploration to delineate measured resources is likely to be a value-destructive exercise for the companies concerned. Historically, these have tended to be 'bulk' in nature. However, this feature of valuations has now broadened to encompass more than half of the metals and minerals analysed by Edison. Exceptions – for which it is apparently value-adding in order to delineate measured resources – include gold, iron ore, nickel, SOP brine, zinc, tungsten and vanadium.

### Equity markets provide a fertile environment for prospective ground…

In contrast to earlier periods, equity markets now demonstrate some form of discounting of future exploration success for the majority of metals and minerals. Historically, these have tended to be of a 'bulk' nature (eg iron ore, thermal coal, metallurgical coal, muriate of potash, etc) plus uranium. However, this grouping has now been joined by gold (listed in London) and silver and potentially PGMs, SOP brines, tungsten, vanadium and bauxite.

Conversely, two metals exhibit a positive correlation between resource size and in-situ valuation – ie the larger the resource, the higher the in-situ resource multiple – namely gold assets listed on the ASX and zinc.

### …albeit amid a general environment of risk averseness

Notwithstanding the above conclusions, Edison's analysis of our notional gold mining company, NonSuch Gold (see page 56), indicates an overall environment of general risk averseness on the part of institutions and investors. With respect to sovereign/political/jurisdictional risk, whereas Edison concluded in October 2016 that, all other things being equal, investors would be wary of investing in an 'average' project in some 22 jurisdictions, in 2017 that had risen to 29. Of 2016's original 22 jurisdictions, 14 (Neuquen, Venezuela, Chubut, La Rioja, Mendoza, Zimbabwe, Uruguay, Honduras, Guatemala, Kenya, Bolivia, Greece, Ecuador and Catamarca) remain, two (St Cruz and French Guiana) have been promoted to investible status, six (Solomon Islands, Guinea, Rio Negro, Kyrgyzstan, Niger and New Caledonia) have been discontinued from the series and there are 14 new entrants, namely Jujuy, Afghanistan, India, Mozambique, Dominican Republic, Myanmar, Panama, Sierra Leone, Hungary, Washington state, Mongolia, South Sudan, France and Indonesia.

At the same time, we estimate that the investible gold grade for an otherwise 'average' gold deposit in an average jurisdiction (eg Serbia, Brazil, Turkey, Papua New Guinea, Tasmania, Greenland, China, Namibia and/or Mexico from the point of view of sovereign risk, as measured by the Fraser Institute Investment Attractiveness survey score and with average engineering, metallurgical and management characteristics) has risen from 1.66g/t in 2016 to 1.82g/t in 2017.

## Price to NPV analysis

For the first time in this series of reports, Edison performed a price to project NPV analysis for a sample of 63 companies. The analysis covers gold, silver, uranium, copper and zinc juniors, and three types of studies – preliminary economic assessments (PEAs), pre-feasibility studies (PFSs) and bankable feasibility studies (BFSs).

In conducting its analysis, Edison concluded that the 'average' project has a published NPV of US$433.1m and an average IRR of 43.2%. Within this context, we observed that markets are more sceptical about projects with IRRs below 30%, but that the distribution of valuations relative to project economics is extremely skewed to the right, which renders mean values of very limited use in analysing individual companies (ie in many instances, there are no companies that trade at valuations close to the mean owing to the skew of the distribution – see pages 63-65). In addition, there is an apparent 'anomaly', whereby valuations are lower for companies with projects at PFS stage than they are for companies with projects at PEA stage:

**Exhibit 6: Company EV as percent of attributable project NPV (%), by study type, statistical summary**

| Study type | Minimum | Mode interval | Mean (excl outliers) | Mean | Maximum | Range |
|---|---|---|---|---|---|---|
| PEA | -13.1% | 0-10% | 18.9% | 54.0% | 427.1% | 440.2% |
| PFS | -13.4% | 10-20% | 16.3% | 25.4% | 134.8% | 148.2% |
| BFS | 2.6% | 10-40% | 29.6% | 66.6% | 428.3% | 425.7% |
| All studies | -13.4% | 0-10% | 22.9% | 52.4% | 428.3% | 441.7% |

Source: Edison Investment Research, Thomson Reuters Datastream, company sources

This may be explained by the apparent evolution of IRRs as a company progresses a project from PEA stage to BFS stage via PFS stage. Nevertheless, it is an anomaly of which companies should be aware.

In determining a company's valuation with respect to a number of variables therefore, we can conclude:

- The most important factor in determining a company's valuation is its project grade. Moreover, this is particularly true for companies with early-stage PEA and PFS level projects.
- Similarly, IRRs are very important for early-stage projects but become less so as the project is developed through to BFS. Ironically, from a statistical perspective, there is little or no correlation (and certainly not a statistically significant one) between project grades and IRRs at almost any stage of a project's development. Nevertheless, statistically speaking, it is preferable to bring any project to the market with an IRR of at least 19.4% at PEA level.
- Jurisdiction is (apparently) not statistically significant at all until a project attains BFS level status and, even then, there will be exceptions.
- Project size becomes more important in determining a company's valuation, but could never be said to be significant at any stage.

However, none of the above factors appear sufficient to confer 'exceptional' valuations on a company. By a process of elimination therefore, of the six principal risks facing a junior mining company, Edison would conclude that only one – management – is likely to be responsible for a disproportionate valuation relative to the tangible and financial characteristics of a project. As such, the apparent primacy of grade in the determining a company's valuation may indicate a 'tick box' approach by the market in general, which may afford opportunities for discerning investors (see our note, *Mining investments: From exploration to production, The long and the short of it*, published in October 2016).

## Rationalising P/NPV with discount rates

Edison first introduced differentiated market derived discount rates for companies at different stages of development in its report, Gold: New benchmarks for old, published in November 2012, and updated them in subsequent reports. Our most recently updated discount rates (to be applied to dividends rather than cash flows) are as follows:

**Exhibit 7: Market derived discount rates for companies at various stages of development (%)**

| | Scoping study/PEA | PFS | BFS | Development | Ramp-up | Production |
|---|---|---|---|---|---|---|
| Max discount rate (%) | 69.0 | 66.0 | 64.0 | 62.0 | 60.0 | 55.0 |
| Mean discount rate (%)* | 35.0 | 33.0 | 30.0 | 27.0 | 24.0 | 17.0 |
| Minimum discount rate (%) | 15.0 | 13.0 | 10.0 | 8.0 | 5.0 | 0.0 |

Source: Edison Investment Research. Note: To be applied in conjunction with long-term metals prices. *As interpreted by Edison Investment Research.

When expressed in terms of the ratio of the company's EV as a percentage of its NPV (at a 10% discount rate, applied to cash flows in the conventional manner), these discount rates yield the following percentages:

**Exhibit 8: NonSuch Gold EV as a percentage of project NPV, by stage of development**

| Percent | Scoping study/PEA | PFS | BFS |
|---|---|---|---|
| Maximum | 50.8 | 76.0 | 115.3 |
| Mid | 1.4 | 10.9 | 25.2 |
| Minimum | -9.1 | -4.6 | -1.0 |

Source: Edison Investment Research

These may be directly compared with those percentages derived from Edison's EV/NPV analysis in Exhibit 9, presented below, transposed for easier comparison:

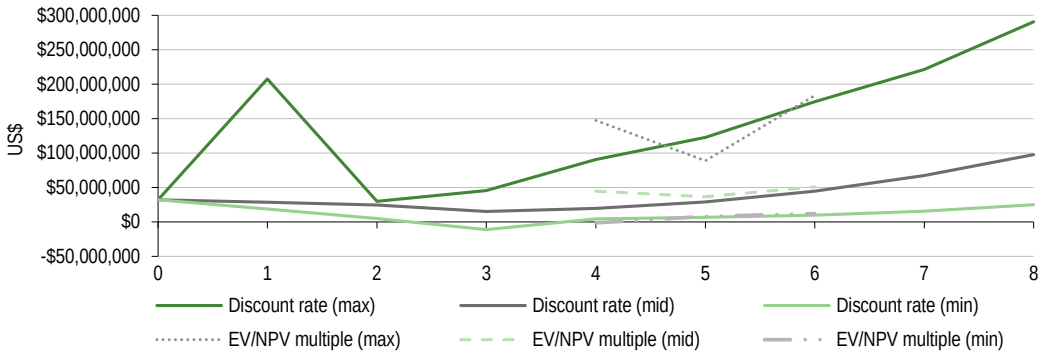
**Exhibit 9: Company EV as percent of attributable project NPV (%), by study type, ordinarily valued companies, excluding statistical outliers**

| Percent | Scoping study/PEA | PFS | BFS |
|---|---|---|---|
| Maximum | 90.0 | 52.6 | 121.5 |
| Mean | 18.9 | 16.3 | 29.6 |
| Minimum | -13.1 | -3.7 | 2.6 |

Source: Edison Investment Research

Depicted graphically, the effect on a company's valuation from using either one of these two methods of valuation is as follows:

**Exhibit 10: NonSuch Gold valued with respect to 1) discount rates and 2) EV/NPV multiples, compared (US$)**




Source: Edison Investment Research. Note: 4 – Scoping study/preliminary economic assessment (PEA); 5 – Pre-feasibility study (PFS); 6 – Bankable feasibility study (BFS); 7 – Development; 8 – Production ramp-up.

Edison believes that the results of these two distinct methods for valuing development stage projects are mutually reinforcing and that the valuation benchmarks summarised in Exhibits 6 and 7 may therefore be used with confidence in assessing the value of mining projects and/or junior mining companies. Note that the 'anomaly' whereby the range is narrower and the mean lower for companies with PFS compared to PEA level projects valued according to the EV/NPV method. As such, Edison recognises that, in comparison to its discount rate valuation, which implies a valuation trough at scoping study stage, there is a risk of that trough extending into PFS stage, potentially partly depending on how the IRR of the project develops through that evolutionary phase.

## The gold price

In common with past reports, Edison has updated its gold price forecasts, derived with respect to its historical correlation with the total US monetary base and also with inflation, as measured by the US Consumer Price Index (CPI). We believe that this analysis – especially in respect of the total US monetary base – is particularly apt, given the US Federal Reserve's plans to shrink its balance sheet over the course of the next five years. In 2017 however, owing to the unprecedented breakdown in the historical relationship between the total US monetary base and inflation, we have also introduced an analysis that forecasts the price of gold based on its historically statistically significant relationship with US currency in circulation.

## The big shrink

When Janet Yellen announced the end of its bond buying programme in October 2014, the Federal Reserve's balance sheet had reached US$4.5tn (including US$2.5tn of Treasuries and US$1.8tn in mortgage backed securities, or MBS) and the total US monetary base US$3.9tn. By reinvesting principal payments and maturing securities, both have remained at or about that level ever since. At the moment, the Federal Reserve is believed to favour a relatively large balance sheet and therefore a relatively big presence in money markets. In deference to its political masters and the big banks however, it has drawn up plans to shrink its balance sheet in order to minimise its influence in the private sector.

While there was some debate about the precise timing of tapering, on 20 September, the Fed finally set the wheels in motion by announcing that the process would begin in October. In the long term, the Fed said that it plans to keep its balance sheet "appreciably below that seen in recent years but larger than before the financial crisis." Once it falls below US$3.0tn however, there will be a further discussion as to how big the Fed's balance sheet should be once tapering is over. As such, the earliest that the Federal Reserve could reasonably start to expand its balance sheet once again is mid-2020. Over the course of the entire balance sheet reduction programme however, Edison's forecasts for combined Treasury bond and mortgage backed security (MBS) run off per annum are as follows:

**Exhibit 11: Projected reduction of Federal Reserve's assets, by year**

| Year | Reduction (US$bn) | Percentage of total (%) |
|---|---|---|
| 2017 | 20 | 1.4 |
| 2018 | 360 | 24.3 |
| 2019 | 463 | 31.3 |
| 2020 | 515 | 34.8 |
| 2021 | 122 | 8.2 |
| Total | 1,480 | 100.0 |

Source: Edison Investment Research

Given this contraction in assets, we forecast that the total US monetary base will decline to US$2.4tn in 2021 (below the level that it was at before QE3 was announced in September 2012), before resuming an upward trajectory again at its long-term growth rate of 6.0% per annum.

The effect of the Federal Reserve successfully reducing its balance sheet by US$1.48tn and this being reflected in the monetary base however, would suggest that (on the basis of its past correlation) the gold price should fall to US$661/oz in 2021, before recovering to something close to current levels, in nominal terms, a decade later, in 2032. However, such a 39.2% contraction of the monetary base is without precedent in the modern era (at least since 1913). In the normal course of events, this may be expected to cause strengthening of the dollar, a deep domestic US recession and material downward pressure on prices generally, with all of the attendant risks of precipitating a debt-deflation spiral of precisely the type that QE was intended to avoid. In this case however, it may be possible to avert such an outcome if growth in currency in circulation can be maintained – which we believe is possible, albeit with little room for complacency.

In addition to its historical correlation with the total US monetary base, the gold price also has a historically statistically significant relationship with currency in circulation. In the light of the above therefore, we considered it appropriate to add an estimate of the future price of gold with respect to this measure, in addition to those already existing. The results of this process are provided in the table below for the 14 years from 2017 to 2030, inclusive:

**Exhibit 12: Edison forecast gold price range, 2017-30e (US$/oz)**

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Currency in circulation | 1,145 | 1,082 | 1,315 | 1,606 | 1,622 | 1,532 | 1,593 | 1,610 | 1,637 | 1,821 | 2,053 | 2,245 | 2,451 | 2,271 |
| Monetary base correlation | 1,555 | 1,424 | 1,256 | 1,069 | 1,025 | 1,076 | 1,131 | 1,188 | 1,249 | 1,314 | 1,383 | 1,456 | 1,533 | 1,615 |
| Inflation | 1,232 | 1,010 | 1,143 | 975 | 860 | 1,027 | 1,243 | 1,213 | 1,053 | 1,040 | 992 | 953 | 1,012 | 1,094 |
| Monetary base correlation & cycle | 1,272 | 1,038 | 907 | 730 | 661 | 712 | 796 | 854 | 918 | 835 | 797 | 776 | 896 | 933 |
| Average | 1,301 | 1,139 | 1,155 | 1,095 | 1,042 | 1,087 | 1,191 | 1,216 | 1,214 | 1,253 | 1,306 | 1,358 | 1,473 | 1,478 |
| October 2016 forecast* | 1,328 | 1,324 | 1,451 | 1,603 | 1,647 | 1,635 | 1,694 | 1,741 | 1,796 | 1,899 | 2,018 | 2,113 | 2,213 | 2,245 |
| October 2016 forecast** | 1,200 | 1,154 | 1,184 | 1,314 | 1,299 | 1,224 | 1,281 | 1,359 | 1,413 | 1,517 | 1,464 | 1,431 | 1,420 | 1,499 |

Source: Edison Investment Research. Note: *Negative real interest rate scenario. **Positive real interest rate scenario.

Of note within the context of this analysis is the fact that our updated average forecasts for future years are much closer to our positive interest rate scenario forecasts of October 2016 than our negative interest rate scenario forecasts, suggesting that this is now the market's expectation.

## Gold valued as a currency

Alternatively, it is possible to value gold as a currency in terms of expected future interest rates and inflation. Adjusting for such 'real' factors as newly mined supply adding to above ground stocks in the future and estimates of world population growth, Edison's gold price forecasts with respect to future inflation and interest rates, over one year, may be summarised as follows:

**Exhibit 13: Gold price predicted as currency with respect to the global inflation of 'real' assets as well as US monetary inflation and interest rates (one year)**

| US$/oz | Future interest rate (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Future inflation rate (%) | 0.0% | 1.0% | 2.0% | 3.0% | 4.0% | 5.0% | 6.0% | 7.0% | 8.0% | 9.0% | 10.0% |
| (3%) | 1,229 | 1,217 | 1,205 | 1,194 | 1,182 | 1,171 | 1,160 | 1,149 | 1,138 | 1,128 | 1,118 |
| (2%) | 1,242 | 1,230 | 1,218 | 1,206 | 1,194 | 1,183 | 1,172 | 1,161 | 1,150 | 1,140 | 1,129 |
| (1%) | 1,255 | 1,242 | 1,230 | 1,218 | 1,206 | 1,195 | 1,184 | 1,173 | 1,162 | 1,151 | 1,141 |
| 0% | 1,267 | 1,255 | 1,243 | 1,230 | 1,219 | 1,207 | 1,196 | 1,184 | 1,174 | 1,163 | 1,152 |
| 1% | 1,280 | 1,267 | 1,255 | 1,243 | 1,231 | 1,219 | 1,208 | 1,196 | 1,185 | 1,174 | 1,164 |
| 2% | 1,293 | 1,280 | 1,267 | 1,255 | 1,243 | 1,231 | 1,220 | 1,208 | 1,197 | 1,186 | 1,175 |
| 3% | 1,305 | 1,293 | 1,280 | 1,267 | 1,255 | 1,243 | 1,232 | 1,220 | 1,209 | 1,198 | 1,187 |
| 4% | 1,318 | 1,305 | 1,292 | 1,280 | 1,267 | 1,255 | 1,243 | 1,232 | 1,220 | 1,209 | 1,198 |
| 5% | 1,331 | 1,318 | 1,305 | 1,292 | 1,280 | 1,267 | 1,255 | 1,244 | 1,232 | 1,221 | 1,210 |
| 6% | 1,343 | 1,330 | 1,317 | 1,304 | 1,292 | 1,279 | 1,267 | 1,256 | 1,244 | 1,233 | 1,221 |
| 7% | 1,356 | 1,343 | 1,330 | 1,317 | 1,304 | 1,292 | 1,279 | 1,267 | 1,256 | 1,244 | 1,233 |
| 8% | 1,369 | 1,355 | 1,342 | 1,329 | 1,316 | 1,304 | 1,291 | 1,279 | 1,267 | 1,256 | 1,244 |
| 9% | 1,381 | 1,368 | 1,354 | 1,341 | 1,328 | 1,316 | 1,303 | 1,291 | 1,279 | 1,267 | 1,256 |
| 10% | 1,394 | 1,380 | 1,367 | 1,354 | 1,341 | 1,328 | 1,315 | 1,303 | 1,291 | 1,279 | 1,267 |

Source: Edison Investment Research

Over four years, they are as follows:

**Exhibit 14: Gold price predicted as currency with respect to the global inflation of 'real' assets as well as US monetary inflation and interest rates (over four years)**

| US$/oz | Future interest rate (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Future inflation rate (%) | 0.0% | 1.0% | 2.0% | 3.0% | 4.0% | 5.0% | 6.0% | 7.0% | 8.0% | 9.0% | 10.0% |
| (3%) | 1,093 | 1,050 | 1,010 | 971 | 934 | 899 | 866 | 834 | 803 | 774 | 746 |
| (2%) | 1,139 | 1,094 | 1,052 | 1,012 | 973 | 937 | 902 | 869 | 837 | 807 | 778 |
| (1%) | 1,186 | 1,139 | 1,095 | 1,054 | 1,014 | 976 | 939 | 905 | 872 | 840 | 810 |
| 0% | 1,234 | 1,186 | 1,140 | 1,097 | 1,055 | 1,016 | 978 | 942 | 907 | 874 | 843 |
| 1% | 1,284 | 1,234 | 1,187 | 1,141 | 1,098 | 1,057 | 1,017 | 980 | 944 | 910 | 877 |
| 2% | 1,336 | 1,284 | 1,234 | 1,187 | 1,142 | 1,099 | 1,058 | 1,019 | 982 | 947 | 913 |
| 3% | 1,389 | 1,335 | 1,284 | 1,234 | 1,188 | 1,143 | 1,100 | 1,060 | 1,021 | 984 | 949 |
| 4% | 1,444 | 1,388 | 1,334 | 1,283 | 1,234 | 1,188 | 1,144 | 1,102 | 1,061 | 1,023 | 986 |
| 5% | 1,500 | 1,442 | 1,386 | 1,333 | 1,283 | 1,234 | 1,188 | 1,145 | 1,103 | 1,063 | 1,025 |
| 6% | 1,558 | 1,498 | 1,440 | 1,385 | 1,332 | 1,282 | 1,234 | 1,189 | 1,145 | 1,104 | 1,064 |
| 7% | 1,618 | 1,555 | 1,495 | 1,438 | 1,383 | 1,331 | 1,282 | 1,234 | 1,189 | 1,146 | 1,105 |
| 8% | 1,679 | 1,614 | 1,551 | 1,492 | 1,436 | 1,382 | 1,330 | 1,281 | 1,234 | 1,190 | 1,147 |
| 9% | 1,742 | 1,674 | 1,610 | 1,548 | 1,489 | 1,433 | 1,380 | 1,329 | 1,281 | 1,234 | 1,190 |
| 10% | 1,807 | 1,737 | 1,670 | 1,606 | 1,545 | 1,487 | 1,432 | 1,379 | 1,328 | 1,280 | 1,234 |

Source: Edison Investment Research

Note the contrast between the results of Exhibit 12 and Exhibit 14, with our forecast price of gold based on US currency in circulation of US$1,606/oz corresponding to apparent negative real interest rates in the order of 7% (green shading) – which compares to a post-gold standard average real interest rate in the US of (positive) 4.02% since end-1971.

## Gold price forecast conclusions

In contrast to previous years, Edison's range of potential future gold price scenarios has widened materially. At the heart of this divergence is the post-2007 breakdown in the relationship between the total US monetary base, currency in circulation and inflation. Historically, the three moved in tandem with one another and gold moved in tandem with them. Contractions in any one of the three were extremely rare.

In the current environment however, the total US monetary base has increased by multiples of itself, while currency in circulation and inflation have remained relatively subdued. While the price of gold has historically demonstrated a closer relationship with the total US monetary base than with currency in circulation, its relationship with both is statistically significant and movements in both effectively presaged the rise in the gold price, in particular from 2006 onwards. As a result, a number of possible scenarios face the gold price, depending upon the direction of the US economy and especially in an environment in which the Federal Reserve is looking to reduce its balance sheet by an unprecedented 33% over the course of the next five years. These range from the benign to, *in extremis*, a debt-deflation spiral akin to the Great Depression. In a number of these scenarios, not only will the price of gold be affected, but also the price of goods and services throughout the US (and potentially the global) economy. Under such circumstances, long-term forecasting becomes extremely difficult. In this case however, unquestionably the most benign outcome as far as the gold price is concerned is the one in which the total US monetary base contracts, but inflation remains subdued, currency in circulation continues to grow and asset prices (including that for gold) remain high.

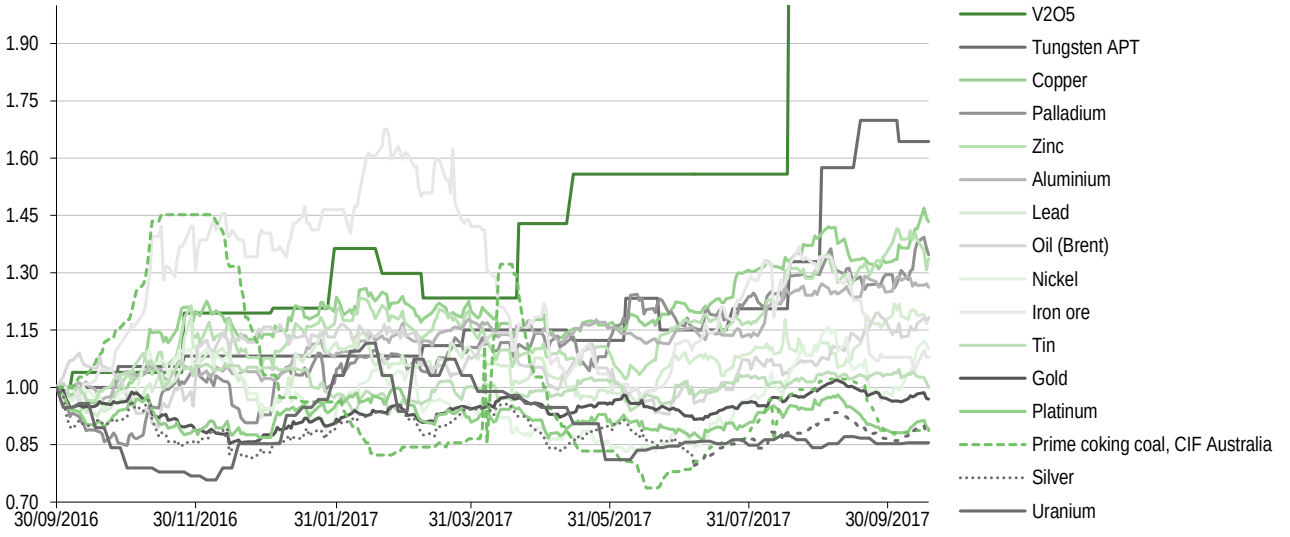
In the light of this, we have shifted the basis of our forecasting from being an average of a number of methods, to one that predicts the price of gold solely in terms of future changes in US currency in circulation. This has the benefit of maintaining a degree of continuity with past forecasts. It is also the closest to the current price of gold in real terms and avoids the necessity of a material reconsideration of costs of production, given their historically close relationship with the price of gold. Nevertheless, we continue to show the results of our other analyses in order that investors may make their own assessments of the future prospects for the price of gold within the parameters of their assumptions regarding the future evolution of the US economy.

## Differentiated in-situ value analysis

In past publications, as well as average values for total resources, Edison has derived differentiated values for the measured, indicated and inferred categories of resources. In this case, the intention is to derive values for resources as they would be experienced by junior exploration companies and to therefore be able to predict what exploration strategies such a company should pursue in order to maximise its returns to shareholders. As a result, specifically excluded from this analysis are all major producing companies, the resources of which will already have benefited from material investment in capital assets by their parent companies and so will have in-situ values that cannot be directly compared with their more junior contemporaries. Compared to previous reports however, the size of the sample of gold explorers has been increased materially with the intention of encompassing as much of the sector as possible. Future reports will attempt to similarly increase the sizes of the samples of junior companies exploring for other metals.

This analysis of the value of in-situ resources has been performed in an environment in which metals' prices have generally been rising – sometimes against expectations. On average, over the course of the past 13 months, commodity prices have increased by 21.6%. In broad terms, since Edison's last in-situ analysis report was published in October 2016, there have been two exceptional performers – namely vanadium and tungsten – and two very strong performers (copper +43.3% and aluminium +26.2%), followed by two solid performers (lead +18.2% and oil +18.2%). Nickel and iron ore were then up approximately 10% each, while gold and tin were largely unchanged. The prices of four metals and minerals – namely platinum, coking coal, silver and uranium – have fallen.

**Exhibit 15: Price performance of major metals and minerals, 30 September 2016 to present (factor)**




Source: Thomson Reuters Datastream, Edison Investment Research

Note, however, that depending on its exact timing (eg June, July, August or September), the actual price movement between the 2016 and 2017 analyses may have been different from that over the entire period. For example, the price of nickel was up 10.1% over the entire period; however, this could be largely attributed to a sharp increase in October 2017. At the time at which Edison's analysis was actually performed in September 2017, the price was almost identical to that at the time of the previous analysis in August 2016.

In general, of the 17 distinct metals and minerals profiled, the prices of seven (gold, uranium, silver, platinum, nickel, MOP and graphite) declined since Edison's last note on the subject (*Mining overview: Normalisation augers well for exploration*, published in October 2016). In the same

timeframe, the prices of nine (iron ore, SOP, copper, zinc, tungsten, vanadium, lithium, metallurgical coal and thermal coal) have risen, while one (bauxite) is ostensibly unchanged (despite the fact that aluminium was one of the best performing metals over the course of the past 13 months).

Similarly, the in-situ values of eight metals and minerals (namely copper, nickel, metallurgical coal, SOP, SOP brines, tungsten, spodumene lithium and graphite) have declined since October 2016 in both nominal and percentage terms, while the in-situ values of 10 (gold, uranium, iron ore, platinum, thermal coal, MOP, zinc, vanadium, lithium and bauxite) have increased. However, not all of the metals and minerals that saw price increases also saw in-situ values increases and vice versa. Exceptions were:

- In-situ values declined in both nominal and percentage terms, despite prices rising, thereby implying either that the equity markets may be discounting future falls in their associated commodity prices or that equity markets are undervaluing junior exploration companies with such resources: copper, metallurgical coal, SOP, SOP brines, spodumene lithium and tungsten.
- In-situ values increased in both nominal and percentage terms, despite prices falling, thereby implying that the equity markets may be discounting future rises in their associated commodity prices or that equity markets are overvaluing junior exploration companies with such resources: gold, uranium, platinum, MOP and bauxite.

In addition, in contrast to prior years, equity markets now demonstrate some form of discounting of future exploration success for the majority of metals and minerals. Conversely, two metals exhibit a positive correlation between resource size and in-situ valuation – ie the larger the resource, the higher the in-situ resource multiple – namely zinc and gold assets listed on the ASX.

This and other results are considered in detail in the individual sections below.

## Gold

Owing to its larger ambient sample size anyway, this report also calculates relative values of in-situ gold ounces differentiated with respect to the market in which they are listed for the world's three major mining finance centres (London, Canada and Australia) – as well as being differentiated by JORC category.

**Exhibit 16: Global average value of in-situ explorers' gold resources, by listing, US$/oz**

| | June 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| London market | 17.88 | 10.27 | 7.33 | 10.34 | 86.74 | 28.39 | 10.51 | 31.17 | 70.01 | 25.00 | (2.86) | 19.50 |
| Canadian market | 47.49 | 6.92 | 11.64 | 15.68 | 87.52 | (8.46) | 6.00 | 12.81 | 74.34 | (1.87) | 3.47 | 12.94 |
| Australian market | 98.57 | 36.58 | 7.33 | 31.27 | 226.06 | 15.15 | 5.51 | 43.47 | (86.05) | 58.85 | 4.85 | 4.85 |
| Arithmetic mean | 54.65 | 17.92 | 8.77 | 19.10 | 133.44 | 11.69 | 7.34 | 29.15 | 19.43 | 27.33 | 1.02 | 12.43 |
| Geometric mean | 43.70 | 12.89 | 11.00 | 17.54 | 35.66 | 15.65 | 7.61 | 16.84 | 22.96 | 16.13 | 3.23 | 13.15 |

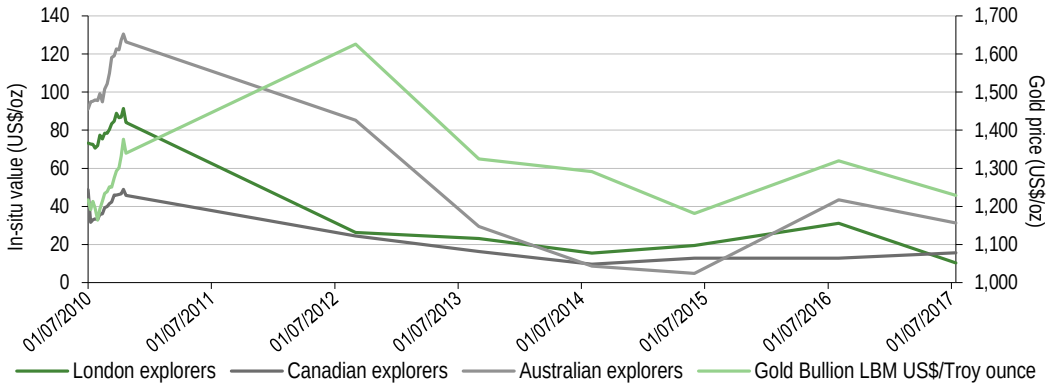
Source: Edison Investment Research, company sources, Thomson Reuters Datastream

With more companies in the sector than London and Australia combined, Canada accounted for 81.5% of the total ounces analysed and 92.3% of the tonnes analysed and therefore has a disproportionate weighting in the geometric mean. Nevertheless, it is pleasing to see the convergence of the geometric and arithmetic means, potentially indicating that the sample size of the gold analysis is now of a sufficiently large size to negate the effect of statistical outliers.

As in previous years, the analysis was complicated by a lack of companies with resources in the inferred category only. In London and Australia, for example, there were only two companies in each market that met this criterion. Moreover, the rating of those companies listed in London with inferred resources only appeared inconsistent with both past observations and the implied values of measured and indicated ounces – although, for the first time, it was consistent with the London market apparently ascribing value to future resources discoveries. For the purposes of this analysis therefore, the value of inferred resources quoted in the London market was deemed to be the same as those quoted in Australia. Otherwise, a number of other features of the results are immediately apparent:

- The values of relatively early-stage inferred and indicated ounces in both Canada and Australia have increased at the expense of the value of measured ounces.
- Globally, the geometric average value of an average ounce is little changed compared to that in August 2016, despite the fact that the gold price declined from US$1,320/oz to US$1,228/oz in the intervening time.
- The average value of ounces quoted in the London market is lower than that observed in both of the other two markets for the first time since this series of analyses began.

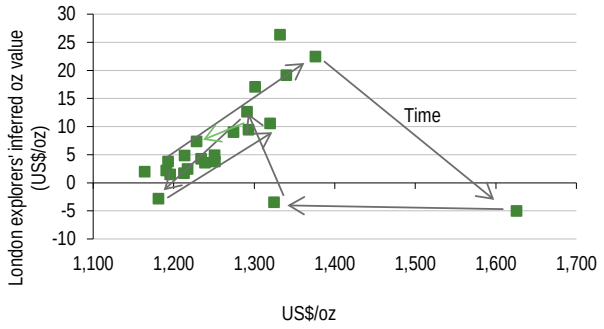
**Exhibit 17: Average value of in-situ ounces listed in London, TSX and ASX vs gold price, July 2010 to July 2017 (US$/oz)**




Source: Edison Investment Research

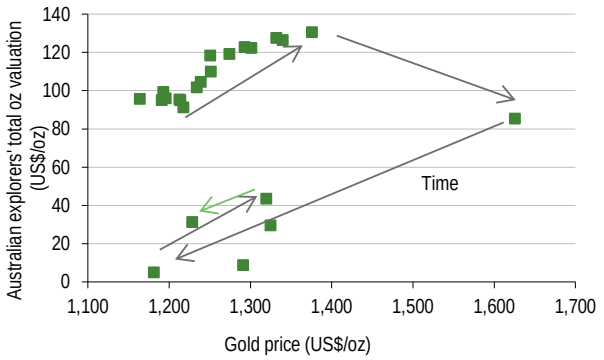
- Valuations overall remain consistent with bear market conditions, with the possible exception of the value of inferred ounces listed in London.

**Exhibit 18: London inferred oz value vs gold price (US$/oz), 2010-2017**




Source: Edison Investment Research

**Exhibit 19: ASX average oz value vs gold price (US$/oz), 2010-2017**



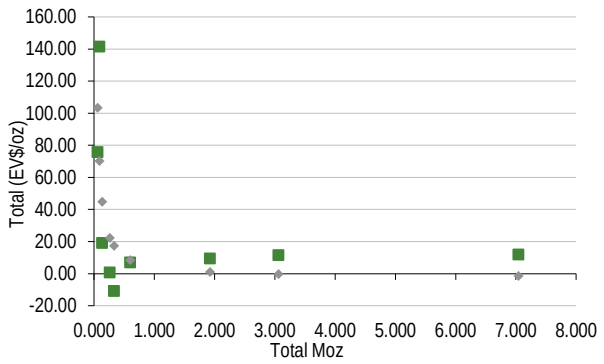

Source: Edison Investment Research

- There is a logical progression (albeit at different orders of magnitude) in the values of inferred, indicated and measured ounces in the London and Australian markets, but the Canadian market still (at least since August 2014) appears to apply a material discount to the value of indicated ounces. The value of a 'blended' indicated and inferred ounce listed in Canada is US$9.58/oz. Nevertheless, this represents a sharp recovery compared to its values of US$1.92/oz in August 2016 and US$2.48/oz in June 2015.

Two features of the analysis that are not immediately apparent relate to the relationships between resource value and resource size and grade.

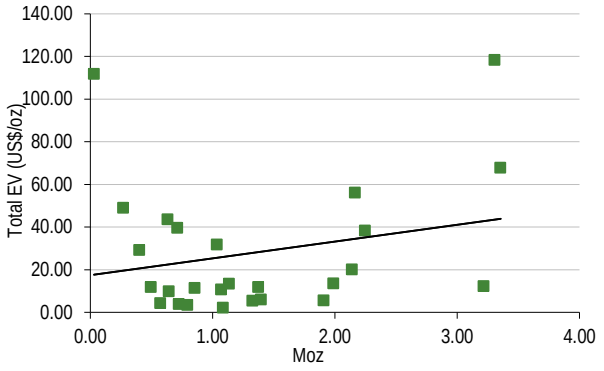
In the case of the former, for the first time in the course of these reports, there is statistically significant evidence that the London market has started to ascribe value to resources not yet formally delineated. At the same time there is some evidence (albeit weak and not statistically significant) that the Australian market may be taking the opposing view – ie that larger resources deserve to attract premium ratings:

**Exhibit 20: Graph of resource size (Moz) vs resource multiple (US$/oz) for London-listed gold explorers**




Source: Edison Investment Research

**Exhibit 21: Graph of resource size (Moz) vs resource multiple (US$/oz) for ASX-listed gold explorers**

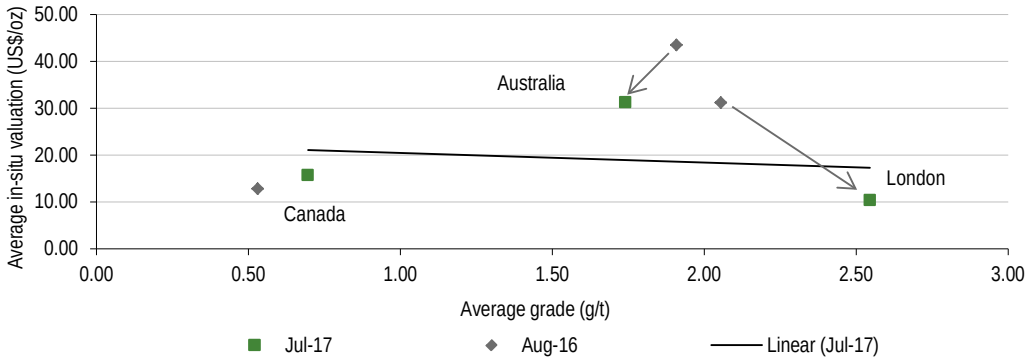



Source: Edison Investment Research

The implication of the London graph, in particular, is significant in that it implies a higher, earlier valuation for companies with small resources, but suggests that it is then harder for managements to increase those valuations in the absence of a disproportionate increase in defined resources (all other things being equal). By contrast, the ASX graph suggests a lower initial valuation, but a disproportionately fast uplift in EV as both resources and their ratings increase concurrently.

Within this context, investors should be aware of the lower overall average grade associated with the sample of companies listed in Canada, of 0.70g/t, compared to 1.74g/t in Australia and 2.55g/t in London. Relative to their ratings (and historical averages), these grades may be depicted as follows:

**Exhibit 22: Average in-situ valuation (US$/oz) vs average grade (g/t), selected markets**




Source: Edison Investment Research

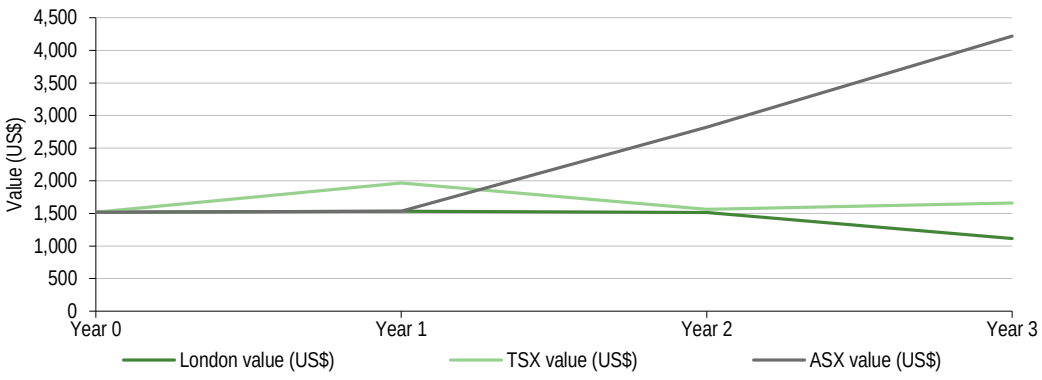
Notwithstanding the continued bear market valuations of in-situ ounces however, there nevertheless exists the possibility of a positive return for investors on exploration dollars in at least the London and Australian markets.

## Financial returns on the gold exploration dollar

In the publication Gold: Valuation benchmarks are obsolete, Edison, in collaboration with BDO, calculated global, average costs of discovery of US$7.16 per inferred ounce, US$10.50 per indicated ounce, US$36.82 per measured ounce and US$8.81 per average ounce.

Companies with indicated and inferred ounces only have them in the proportion 50:50, inferred:indicated, respectively, while companies with measured, indicated and inferred resources have them in the proportion 21:54:25, respectively. On the basis of the unit cost estimates derived above, the cost to drill up a typical, average deposit of 100oz, in the ratio 21:54:25 would therefore be US$1,516 in aggregate. At the unit values shown in Exhibit 16, these resources would be worth US$1,112 in London (vs US$3,347 in August 2016), US$4,219 in Australia (vs US$4,947) and US$1,658 in Canada (vs US$1,263), representing returns of -26.6% in London, +178.3% in Australia and +9.4% in Canada. The global average return is 24.4%, with an evolution over time as follows:

**Exhibit 23: Average gold exploration value evolution over time (US$)**




Source: Edison Investment Research

Note that, in year 0, the company has cash of US$1,516; in year 1, it has a resource of 100 inferred oz and cash of US$800; in year 2, it has a resource of 50 inferred oz and 50 indicated oz and cash of US$634; and in year 3, it has a resource of 25 inferred oz, 54 indicated oz and 21 measured oz and no cash. At the end of the campaign, the percentage value attributable to each category of resources in each market is as follows:

**Exhibit 24: Average gold resource values, by category, selected markets (%)**

| Resource category | London | Canada | Australia |
|---|---|---|---|
| Measured | 34 | 60 | 49 |
| Indicated | 50 | 23 | 47 |
| Inferred | 17 | 18 | 4 |
| Total | 100 | 100 | 100 |

Source: Edison Investment Research. Note: Numbers may not add up owing to rounding.

## Uranium

In contrast to the rather staid performance of the value of in-situ gold resources within the context of a weak overall gold market, the value of in-situ uranium resources demonstrated a material bounce, notwithstanding continued pressure on the price of uranium itself (see Exhibits 25 and 15).

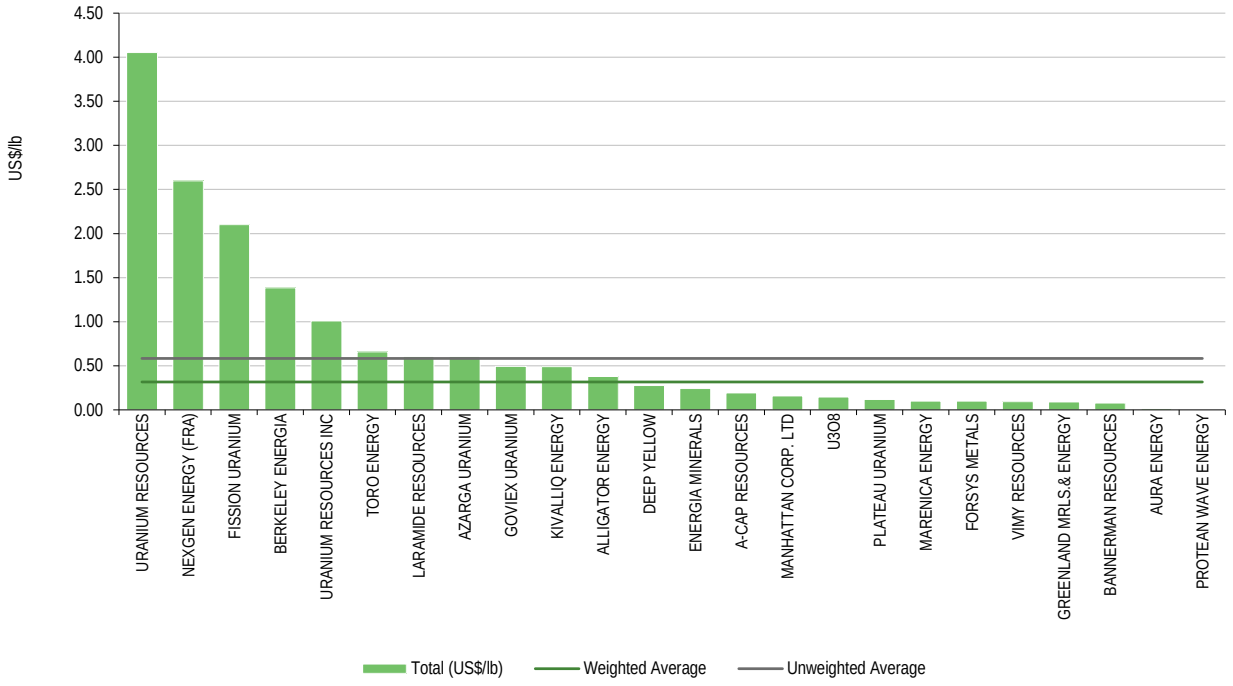
**Exhibit 25: Global average value of in-situ explorers' uranium resources (US$/lb)**

| | July 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ $U_3O_8$ value | 6.93 | (0.53) | 0.50 | 0.32 | 3.40 | (0.64) | 0.28 | 0.15 | (1.30) | 0.92 | 0.07 | 0.21 |
| Cost of discovery* | 1.37 | 0.92 | 0.09 | 1.02 | 1.37 | 0.92 | 0.09 | 1.02 | 1.37 | 0.92 | 0.09 | 1.02 |

Source: Edison Investment Research, company sources, Thomson Reuters Datastream. Note: *See Gold: The value of gold and other metals, published in February 2015.

While none of the samples demonstrated any obvious anomalies, the fact that the implied value of indicated resources is negative, as well as being at a discount to the implied value of inferred resources, is, at first glance, nonsensical. Nevertheless, the fact that the implied in-situ values of higher confidence pounds is lower than the value of lower confidence ones has been a feature of the market for some years now. One possible interpretation is that the market values uranium explorers on the basis of total pounds in the ground, rather than pounds differentiated by geological category:

**Exhibit 26: Implied value of total uranium lbs in-situ**

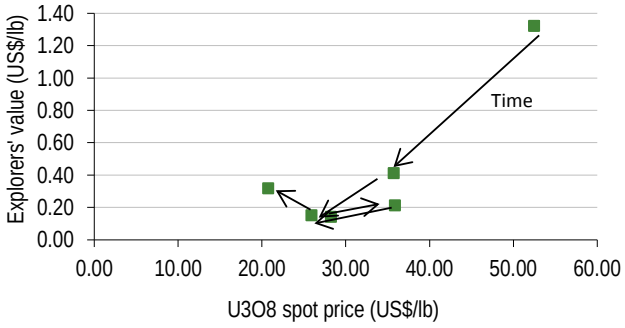



Source: Edison Investment Research

Considered thus, four companies' in-situ values fall more than one standard deviation away from the weighted average – being the top four. Three of these may be considered special cases: Uranium Resources, on account of its small resource size (see size discounting, below) and NexGen and Fission on account of their locations on the western edge of the Athabasca Basin (widely viewed as a premium location).

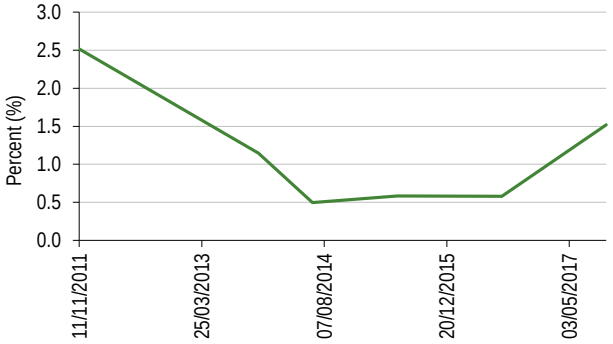
Nevertheless, considered within the historical context, the average in-situ value of uranium pounds has demonstrated a material recovery in both absolute and relative terms and appears consistent with equity markets discounting a recovery in commodity markets (albeit one that is, as yet, intangible).

**Exhibit 27: In-situ value of total uranium resources vs spot price of uranium, 2011-17**




Source: Edison Investment Research

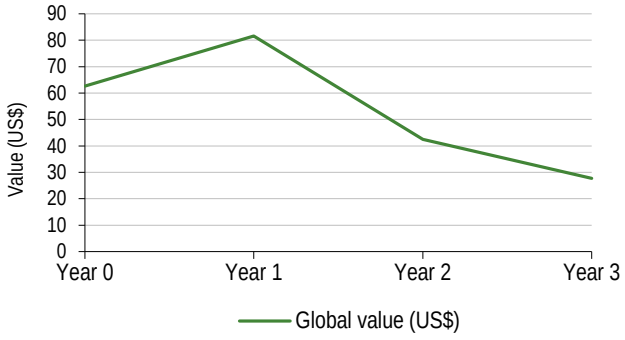
**Exhibit 28: In-situ value of total uranium resources as percent of the spot price of uranium, 2011-17**




Source: Edison Investment Research

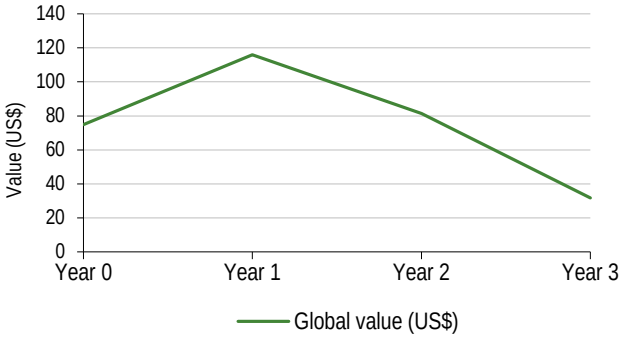
Companies with indicated and inferred ounces only have them in the proportion 82:19, inferred:indicated, respectively, while companies with measured, indicated and inferred resources have them in the proportion 8:67:25, respectively. On the basis of the unit cost estimates detailed in Exhibit 2, above, the cost to drill up a typical, average deposit of 100lb, in the ratio 8:67:25 would therefore be US$74.95 in aggregate. Notwithstanding the rise in average values therefore, returns on uranium spend nevertheless remain negative overall – eg -57.5% for a company seeking to delineate a theoretical 100lb resource at the average percentage categorisations prevailing at the time of writing vs -55.6% in August:

**Exhibit 29: Value evolution of junior uranium explorer developing 100lb resource, 2016 (US$)**




Source: Edison Investment Research

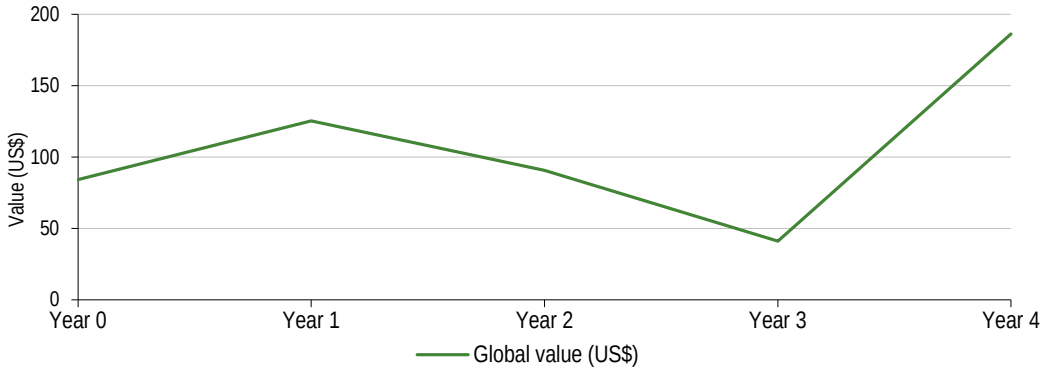
**Exhibit 30: Value evolution of junior uranium explorer developing 100lb resource, 2017 (US$)**




Source: Edison Investment Research

Within this context however, it is notable that most of the value destruction between years 2 and 3 (ie when drilling up measured resources for the first time) arises as a result of the simultaneous increase in indicated resources and loss of inferred resources. In fact (as can be seen from the values in Exhibits 2 and 25) upgrading just indicated resources to the measured category is strongly value adding. Exhibit 31 therefore performs the same analysis, including one additional year in which the same percentage of indicated resource promotion into the measured category occurs in year 4 as in year 3, but with no concomitant increase in inferred resources promoted to the indicated category:

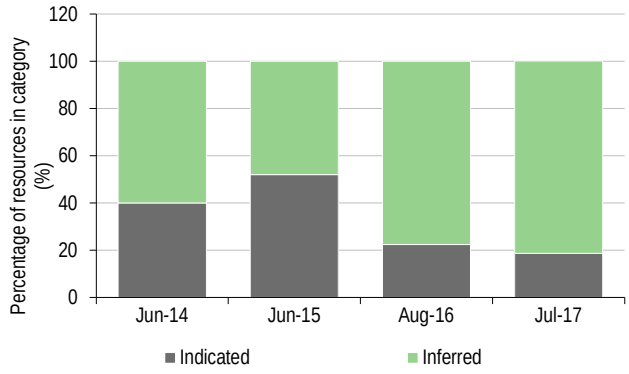
**Exhibit 31: Value evolution of junior uranium explorer developing a 100lb resource, 2017 (US$), including additional year devoted to specific delineation of measured resources**




Source: Edison Investment Research

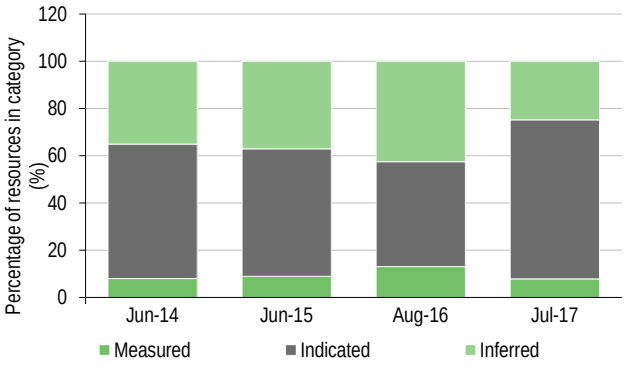
Assuming this analysis to be representative of the uranium junior industry, then it would behove managements to attempt to maximise their inferred and measured resources with respect to their indicated ones. Whereas there is tangible evidence of this for companies with inferred and indicated resources only over the course of the past three years, companies with all three categories of resources appear to have taken a retrograde step over the course of the past 11 months in that the percentage of indicated resources appears to have increased:

**Exhibit 32: Categorisation of resources for uranium juniors with indicated and inferred resources only (%)**




Source: Edison Investment Research

**Exhibit 33: Categorisation of resources for uranium juniors with all three categories of resources (%)**

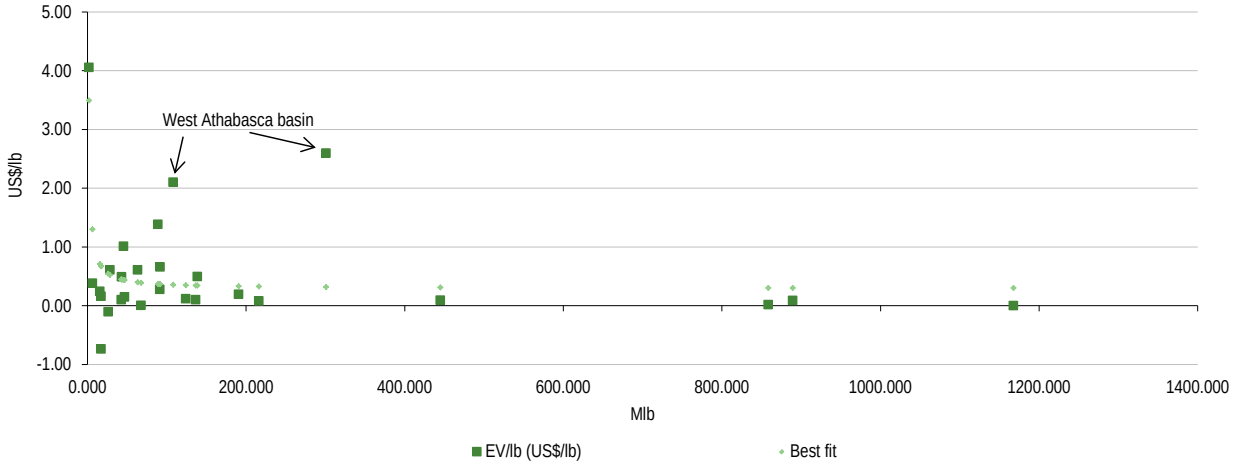



Source: Edison Investment Research

In order to maximise value, it may be hoped that managements have found the increase in the percentage of their resources in the indicated category to be a necessary precursor to an increase in the percentage of resources in the measured category over the course of the next 12 months.

As in previous years however, there nevertheless also exists statistically significant evidence of the market continuing to discount future exploration success among uranium explorers (see Gold: The value of gold and other metals, published in February 2015 and Mining overview: Normalisation augers well for exploration, published in October 2016).

**Exhibit 34: Graph of resource size (Mlbs) vs resource multiple (US$/lb) for $U_3O_8$ explorers, July 2017**




Source: Edison Investment Research

Note that this effect becomes much stronger if the two companies with resources in the West Athabasca basin are excluded from the analysis. Moreover, unlike in previous years, in which there appeared to be a distinctive boundary at about 100Mlb beyond which this effect dissipated rapidly, this no longer appears to be the case.

## Silver

As with gold and uranium, the price of silver was discernibly lower at the time that this analysis was performed in July 2017, when it was US$16.10/oz, than in the previous year, in August 2016, when it was US$18.79/oz.

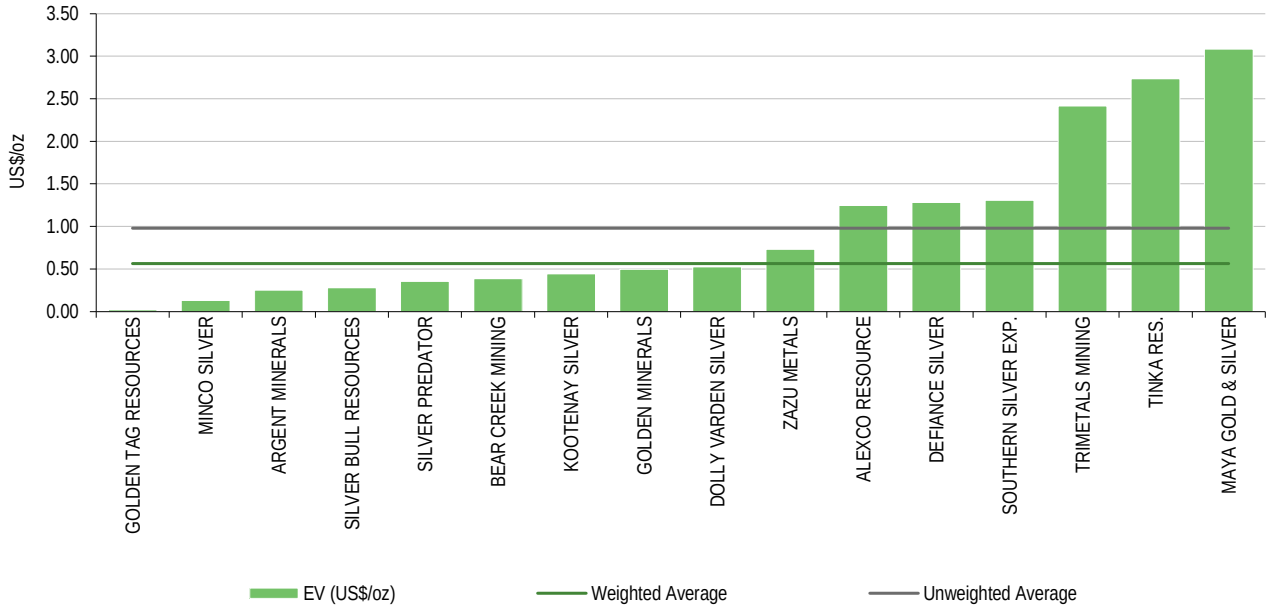
**Exhibit 35: Global average in-situ value of explorers' silver resources (US$/oz)**

| | July 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ silver value | 0.45 | 0.18 | 1.28 | 0.56 | (2.07) | 1.16 | 0.13 | 0.59 | (7.50) | 1.56 | 0.02 | 0.45 |

Source: Edison Investment Research, company sources, Thomson Reuters Datastream

As with uranium, analysis of silver explorers suggests that the market looks upon all ounces equally, rather than differentiating by resource category.

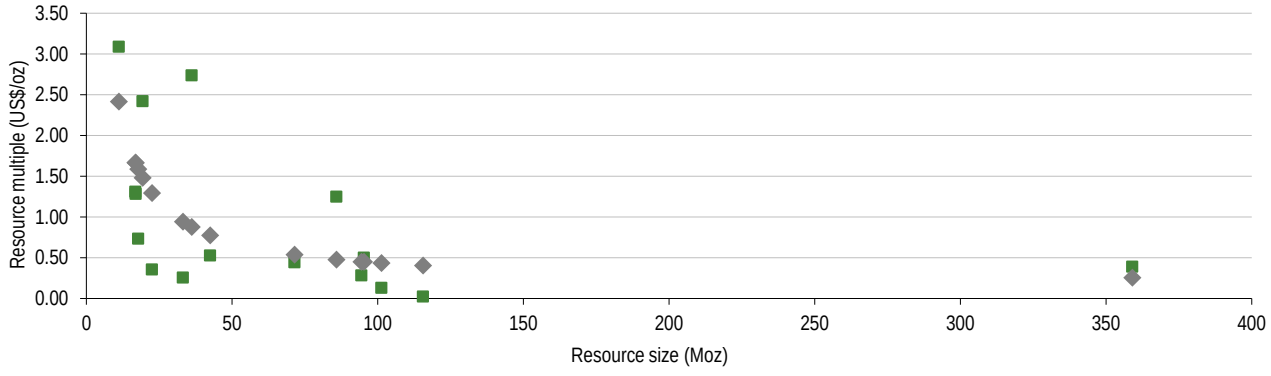
**Exhibit 36: Implied value of total silver oz in-situ (US$/oz)**




Source: Edison Investment Research

An alternative explanation however is that there is now, for the first time since this series of analyses were first performed by Edison, statistically significant evidence that investors are prepared to afford value to companies for resources that have yet to be formally delineated:

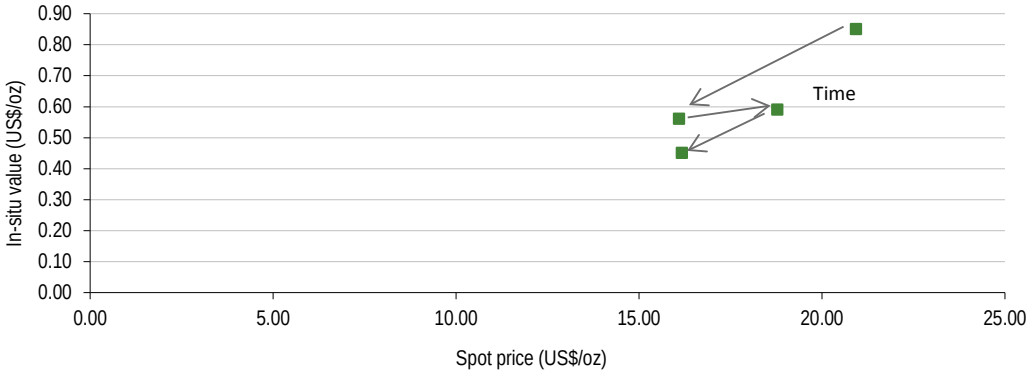
**Exhibit 37: Graph of resource size (Moz) vs resource multiple (US$/oz) for silver explorers, July 2017**




Source: Edison Investment Research

Nevertheless, the overall value of average silver ounces is approximately where it would be expected to be, given the silver price prevailing at the time that the analysis was conducted:

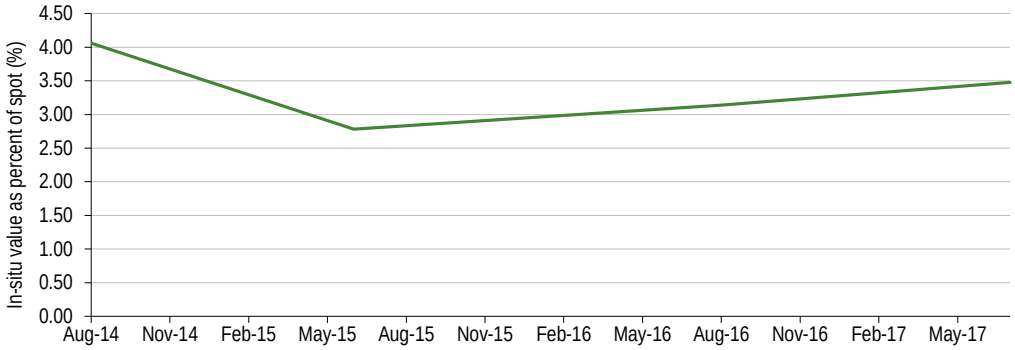
**Exhibit 38: In-situ value of total silver resources vs spot price of silver, 2014-17**




Source: Edison Investment Research

In percentage terms however, in-situ silver resources maintained (or even extended) their premium rating relative to other metals and minerals (see Exhibits 5 and 113), as the average value of in-situ ounces declined by less than the spot price of the metal itself:

**Exhibit 39: In-situ value of total silver resources as percentage of silver spot price, 2014-17**




Source: Edison Investment Research

## Iron ore

At the point at which Edison's iron ore analysis was conducted, the price was actually higher than it had been the previous year (US$72.23/t vs US$57.78/t), confounding orthodox opinion that it would wilt under pressure from steel production capacity cuts in China. In addition, there were relatively material differences to the sample of companies analysed, with seven of the contingent from last year's analysis being excluded and three new (or returning) entrants, being Bellzone, Beowulf and GWR.

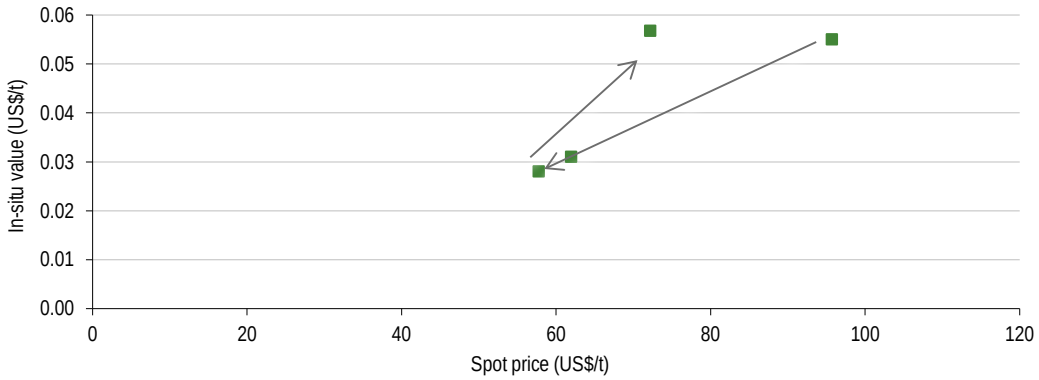
**Exhibit 40: Global average in-situ value of explorers' iron ore resources (US$/t Fe)**

| | August 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ iron ore value | 0.125 | 0.084 | 0.026 | 0.057 | (0.062) | 0.120 | (0.001) | 0.028 | (0.087) | 0.137 | 0.009 | 0.031 |

Source: Edison Investment Research, company sources, Thomson Reuters Datastream

Arguably, as a result, the average in-situ value of iron ore resources increased disproportionately, relative to the price of iron ore itself (Exhibit 41, below):

**Exhibit 41: In-situ value of total iron ore resources vs iron ore spot price, 2014-17**

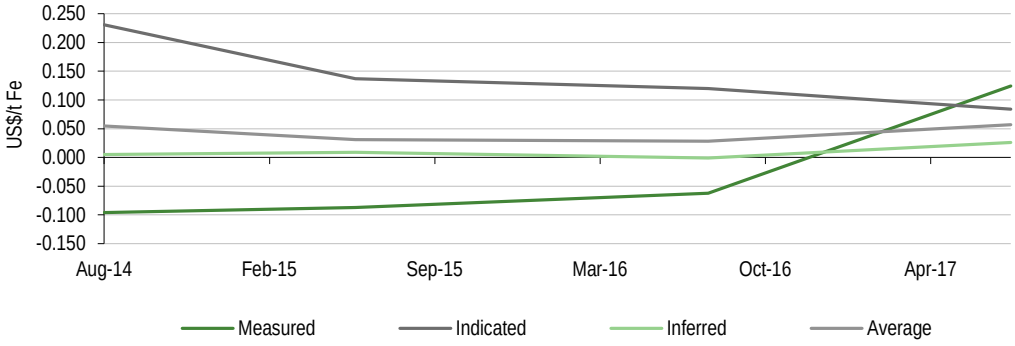



Source: Edison Investment Research

Assuming spot iron ore prices to be 'correct', either iron ore juniors' enterprise values should have been higher in August 2014 (the starting point of the analysis at the top, right hand side of the graph) or they should have been lower in August 2017 (the finishing point) or some combination of the two. An alternative interpretation would be that in-situ values were discounting lower iron ore prices in August 2014 and/or higher ones in August 2017 or some combination of the two.

Nevertheless, on average, for the first time since this series of reports began, the valuation of in-situ iron ore resources conforms to a logical pattern, whereby the value of measured resources is greater than that of indicated resources, which, in turn, is greater than that of inferred resources. Note that this is a result of an increase in the implied value of inferred resources causing a decline in the implied value of indicated resources, which, in turn, caused an increase in the implied value of measured resources.

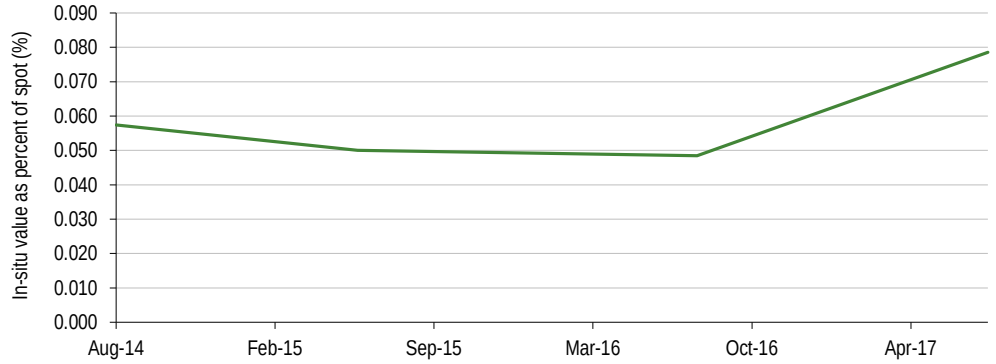
**Exhibit 42: In-situ iron ore resource values, by category, August 2014 to August 2017**




Source: Edison Investment Research

As a result, there was also a percentage increase in the valuation of resources relative to the spot price of iron ore, albeit that percentage remains an order of magnitude below that prevailing during the bull market of 2011/12 when, anecdotally, Edison estimates that in-situ values approximated 1.0% of spot values (see Exhibit 112).

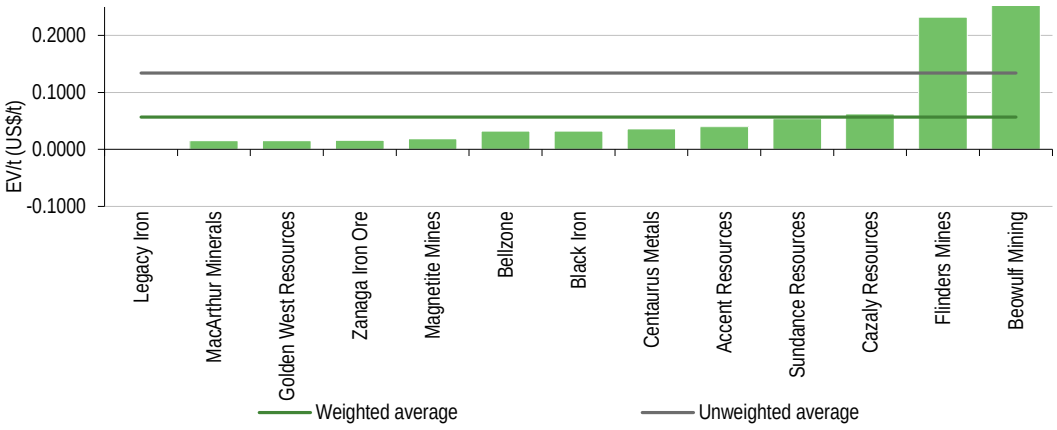
**Exhibit 43: In-situ value of iron ore resources as percentage of iron ore spot price, 2014-17**




Source: Edison Investment Research

At the same time (as with nickel, SOP brine, zinc, tungsten and vanadium), while iron ore juniors may be analysed in terms of the categorisation of their resources, they may also be analysed with respect to total resources:

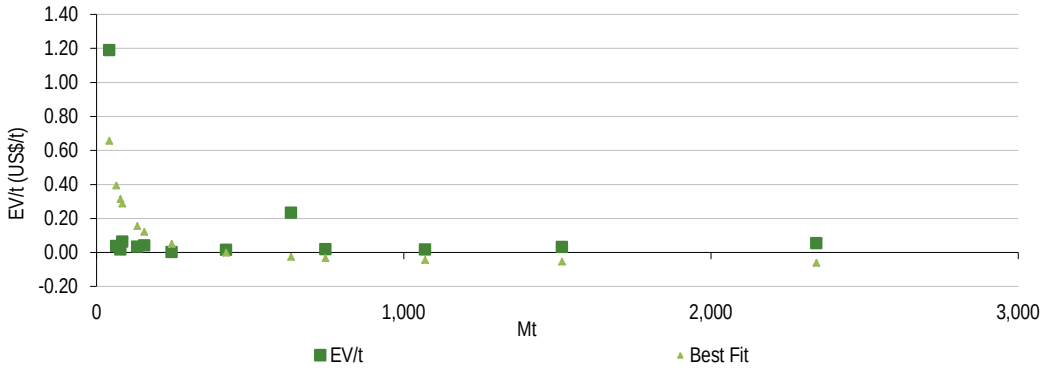
**Exhibit 44: Implied value of total in-situ iron ore resources (US$ per tonne Fe)**




Source: Edison Investment Research

Once again however, there is also statistically significant evidence of the discounting of future discoveries in the sector:

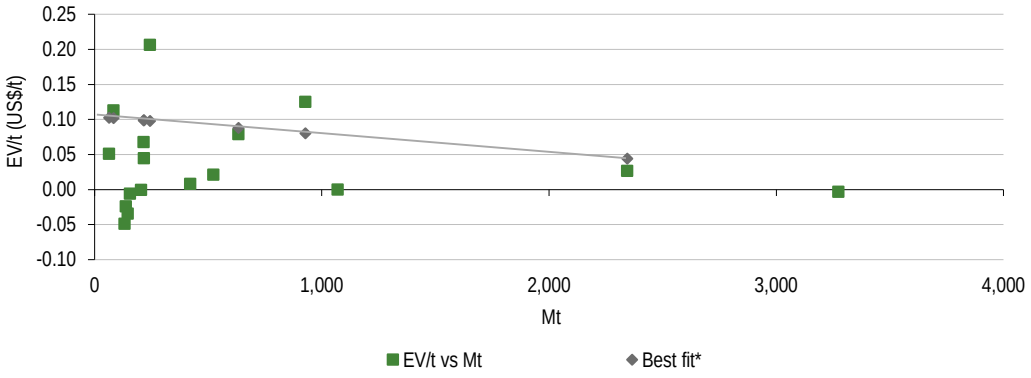
**Exhibit 45: Graph of resource size (Mt) vs resource multiple (US$/t Fe) for iron ore explorers, August 2017**




Source: Edison Investment Research

Note that there is much stronger statistically significant evidence of an inverse relationship between resources size and multiple in 2017 than there was at the time of the equivalent analysis in August 2016:

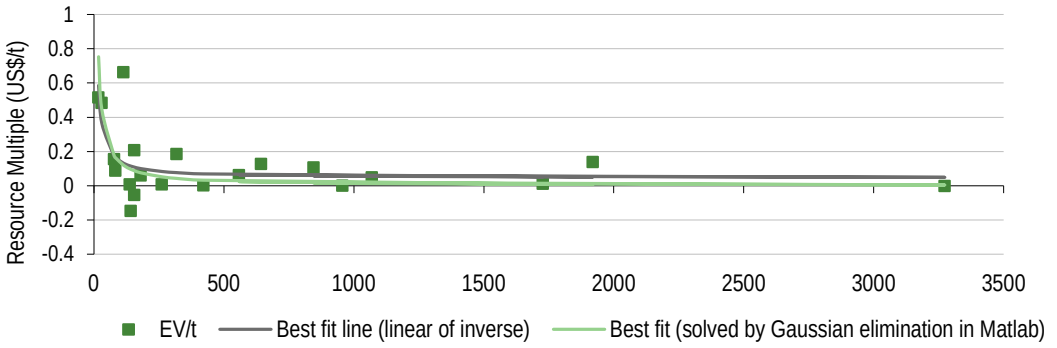
**Exhibit 46: Graph of resource size (Mt) vs resource multiple (US$/t Fe) for iron ore explorers, August 2016**




Source: Edison Investment Research. Note: *Relevant sample only

This suggests that junior companies with small resources in 2017 may be afforded a better valuation upon listing than they would have in 2016, but that managements may then find it difficult to increase that valuation via the delineation of additional resources. In this respect at least, market conditions for iron ore companies appear to be closer to those prevailing in August 2014, rather than those prevailing in 2016 (although investors should note the apparently depressed valuations afforded to companies with resources larger than 750Mt Fe in 2017 vs 2014 – see Exhibit 47 overleaf):

**Exhibit 47: Graph of iron ore resource size (Mt) vs resource multiple (US$/t Fe), August 2014**




Source: Edison Investment Research

## Platinum group metals (PGMs)

The analysis of the platinum sector is complicated by the fact that the sample of explorers is small and there are no explorers with inferred resources only. Inevitably, the sample is dominated by South Africa and the Bushveld complex and therefore a relative absence of both measured and indicated ounces relative to inferred ounces.

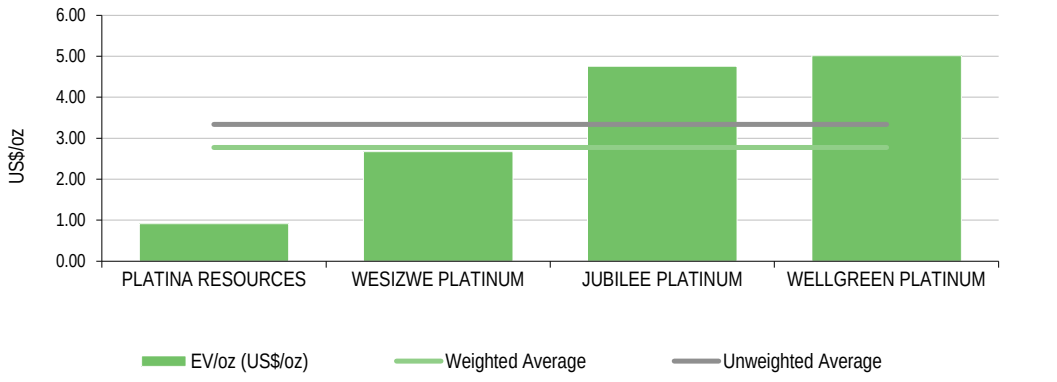
**Exhibit 48: Global average in-situ value of explorers' PGM resources (US$/oz PtE)**

| | August 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ PGM value (US$/oz PtE) | (76.55) | 29.44 | 2.38 | 2.78 | (9.24) | 2.98 | 2.98 | 2.31 | 12.30 | 10.39 | 0.84 | 2.53 |
| Cost of discovery (US$/oz PtE)* | 4.18 | 1.26 | 0.90 | | 4.18 | 1.26 | 0.90 | | 4.18 | 1.26 | 0.90 | |

Source: Edison Investment Research, company sources, Thomson Reuters Datastream. Note: *Maximum cost of discovery derived for Witwatersrand gold ounces (assumed to be comparable to Bushveld PtE oz), see Gold: Valuation benchmarks are obsolete, published in January 2010. PtE = platinum equivalent.

Once again, the analysis is indicative of the fact that the market values PGM explorers with respect to total resources, rather than resources differentiated by geological category:

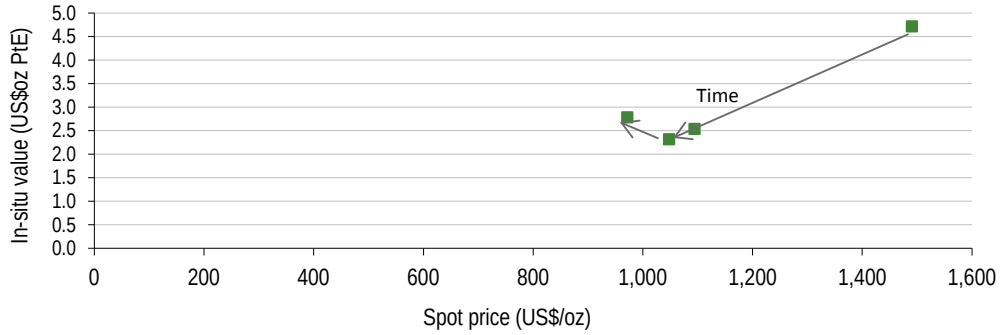
**Exhibit 49: Implied in-situ value of total PGM resources (US$/oz PtE)**




Source: Edison Investment Research

Relative to August 2016 however, it is notable that there has been a recovery in junior equity values relative to the price of platinum. This may be interpreted as the equity markets discounting a recovery in the platinum price. An alternative interpretation would be with reference to the price of palladium, which has been in a notable bull market over the course of the period under review, compared to platinum, which has been in a bear market:

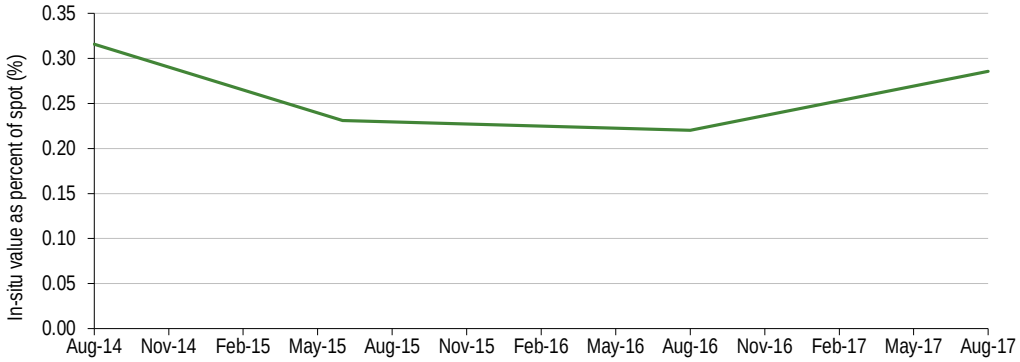
**Exhibit 50: In-situ value of total PGM resources (US$/oz PtE) vs spot price of platinum (US$/oz), 2014-17**




Source: Edison Investment Research

As a result, in-situ values have increased relative to the spot price of platinum, albeit they remain below levels of August 2014 and almost an order of magnitude lower than the equivalent percentages for the gold juniors (presumably evidencing a Bushveld effect similar to a Witwatersrand effect):

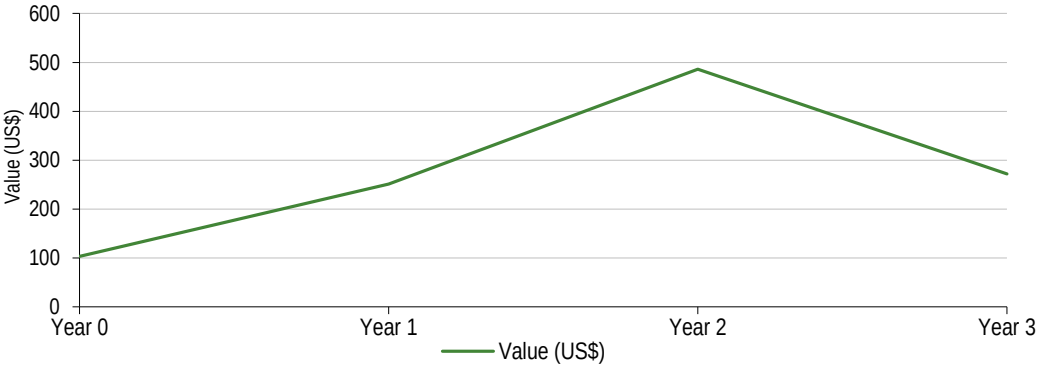
**Exhibit 51: In-situ value of PGM resources as percentage of platinum spot price, 2014-17 (%)**




Source: Edison Investment Research

Nevertheless, the discounted value of measured resources relative to indicated and inferred resources should not be overlooked. Under almost any circumstances, it strongly implies that resource definition up to the indicated category of resources will be value adding, but that it will be value destroying beyond that:

**Exhibit 52: Value evolution of junior PGM explorer developing a 100oz PtE resource**

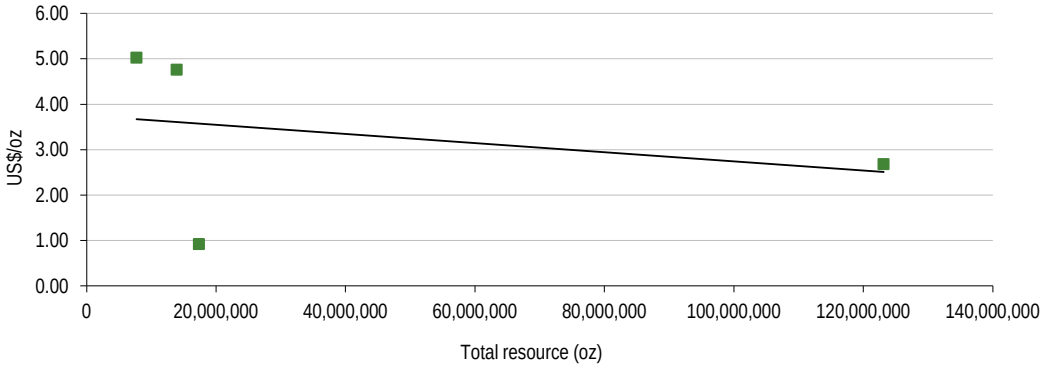



Source: Edison Investment Research

Note that, in year 0, the above company has US$103.44 in cash as its only asset; in year 1, it has a resource of 100 inferred ounces and cash of US$13.44; in year 2, it has a resource of 91 inferred ounces and 9 indicated ounces and cash of US$10.27; and in year 3, it has a resource of 87 inferred ounces, 10 indicated ounces and 3 measured ounces and no cash.

In addition, there is weak (ie not statistically significant) evidence of equity markets discounting future exploration success (Exhibit 53); although, in the case of PGMs, it may be that the relationship is linear, rather than the more commonly observed inverse. The significance of this is that it is then possible to add value to a junior PGM exploration company by increasing its resource base. If the relationship is an inverse one, for example, doubling a company's resource base would typically be accompanied by a halving of the resource multiple, such that the EV of a company would remain the same. In that case, the market might be said to be fully discounting all possible future exploration success. In the case of PGMs however, if a company doubles its resource base, this is accompanied by only a small decline in the resource multiple, such that the company's EV might be expected to nearly double. In this case therefore, the market is only discounting some future exploration success and managements are consequently able to add value to their companies by expanding their resources at an appropriate cost.

**Exhibit 53: Resource size (oz) vs resource multiple (US$/oz) for PGM explorers**




Source: Edison Investment Research

## Nickel

Our nickel analysis has been sub-divided into separate analyses for sulphide and laterite deposits to reflect the different natures and processing requirements of those ore-bodies.

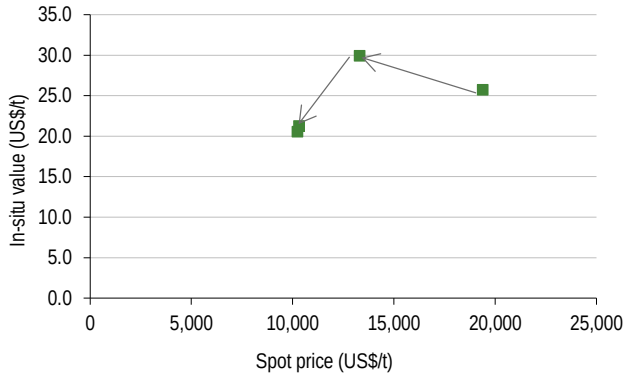
**Exhibit 54: Global average in-situ value of explorers' nickel resources (US$/t)**

| | September 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ nickel value (US$/t) | 95.37 | 16.51 | 4.46 | 16.44 | 106.62 | 22.11 | 5.87 | 19.43 | 60.66 | (39.22) | 58.92 | 18.44 |
| Ditto (sulphide deposits) | 95.50 | 24.29 | 5.83 | 20.51 | 92.24 | 27.50 | 6.44 | 21.20 | 176.38 | (45.69) | 58.92 | 29.87 |
| Ditto (laterite deposits) | 45.55 | 8.63 | 2.65 | 8.15 | 79.02 | 14.38 | 4.67 | 11.27 | (30.33) | 14.09 | 4.57 | 5.21 |

Source: Edison Investment Research, company sources, Thomson Reuters Datastream

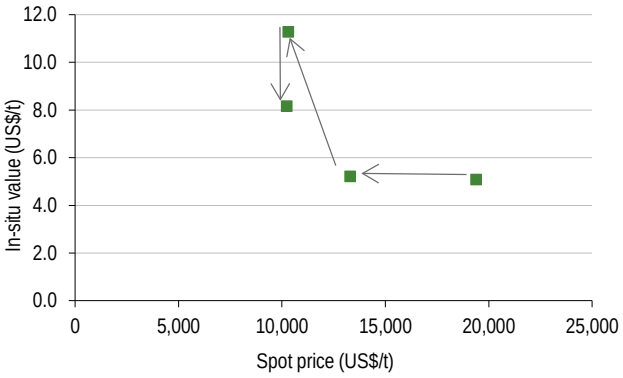
Of immediate note is the premium valuation accorded to sulphide resources compared to laterite ones (as expected). Within that however, it is also notable that sulphide resources have maintained their value over the course of the past year – in which the nickel price is, overall, largely unchanged compared to August 2016 – in contrast to laterite deposits, which have witnessed a marked decline in value.

**Exhibit 55: In-situ value of nickel sulphide resources vs spot price of nickel, 2014-17**




Source: Edison Investment Research

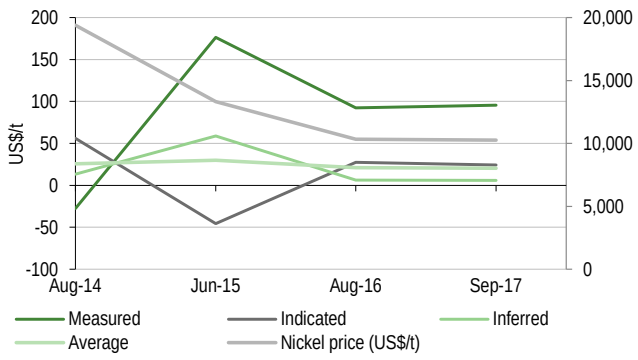
**Exhibit 56: In-situ value of nickel laterite resources vs spot price of nickel, 2014-17**




Source: Edison Investment Research

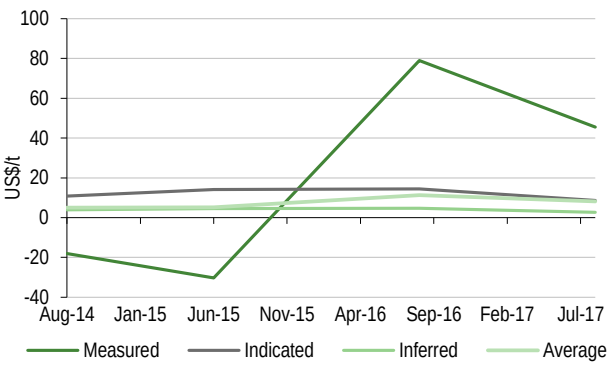
What is more, each category of resources within the nickel sulphide sample has broadly maintained its in-situ valuation, whereas each category of resources within the nickel laterite sample has typically lost 40-50% of its valuation:

**Exhibit 57: In-situ value of nickel sulphide resources vs spot price of nickel, by category, 2014-17**




Source: Edison Investment Research

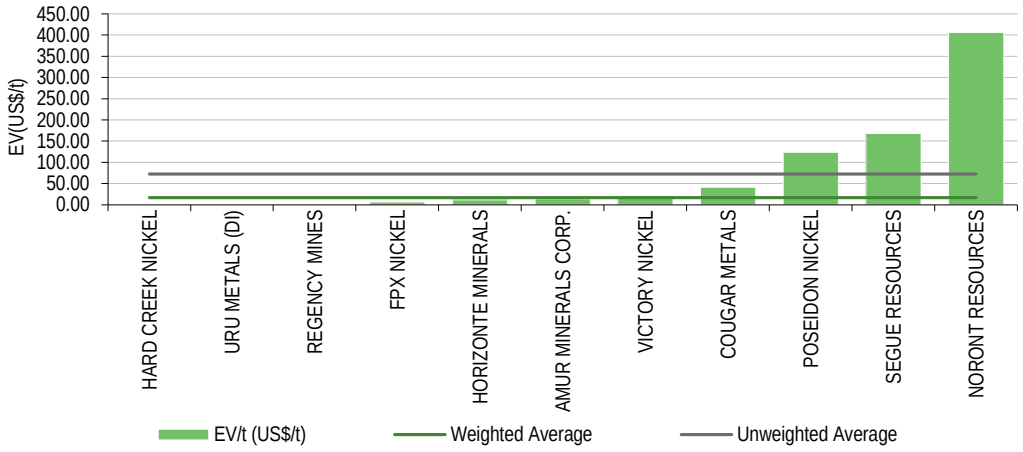
**Exhibit 58: In-situ value of nickel laterite resources vs spot price of nickel, by category, 2014-17**




Source: Edison Investment Research

At just 11 companies, the overall size of the nickel sample was small however. In addition, the only company with inferred resources only (Segue) was a clear statistical outlier. As a result, the differentiated analysis for nickel required an assumption that the value of inferred resources was half way between zero and the value of indicated resources. Nevertheless, in addition to rendering themselves analysable by differentiated resource category, nickel companies may also reasonably be valued with respect to total resources:

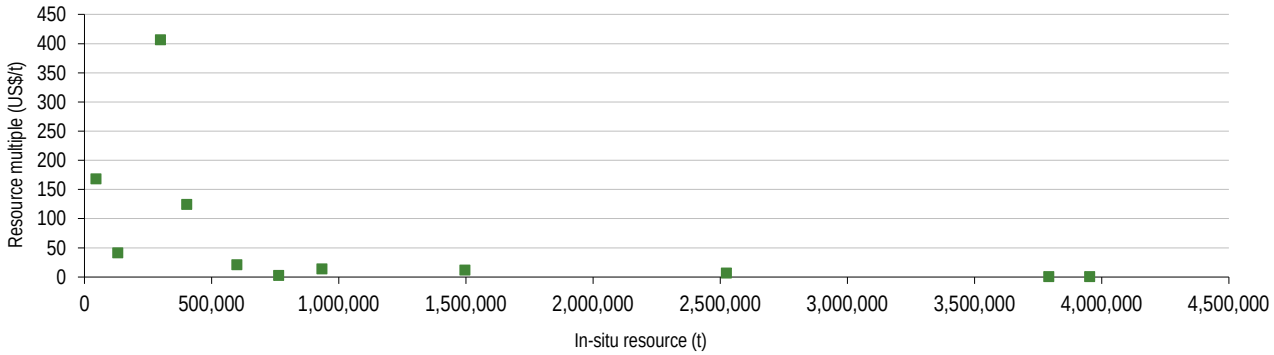
**Exhibit 59: Implied in-situ value of total nickel resources (US$/t)**




Source: Edison Investment Research

In this case, Segue and Noront may be regarded as statistical outliers, being more than one standard deviation beyond the weighted average in-situ value. However, both of these companies have relatively small resources compared to their peers, and so, among other things, this may be attributed to the market's discounting future exploration success, as demonstrated in the graph below.

**Exhibit 60: Resource size (t) vs resource multiple (US$/t) for nickel explorers**




Source: Edison Investment Research

While visually quite compelling, investors should note that, for the number of data points in the sample, in mathematical terms correlation between resource size and resource multiple is not statistically significant at the 5% level and is therefore, at the current time, somewhat a matter for conjecture.

## Potash

Like our nickel analysis, our potash analysis has been sub-divided into separate analyses for companies seeking to produce either sulphate or muriate of potash (SOP and MOP, respectively) and also into brines to reflect the different natures and processing requirements of those products and ore-bodies.

**Exhibit 61: Global average in-situ value of explorers' potash resources, by type (US$/t)**

| | August 2017 | | | | August 2016 | | | |
|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| Sulphate of potash | (3.16) | 1.12 | 0.27 | 0.51 | (6.44) | 1.26 | 0.30 | 0.54 |
| Muriate of potash | (0.84) | 0.25 | 0.11 | 0.05 | (2.76) | 0.83 | 0.11 | 0.02 |
| Brine | 4.47 | 0.36 | 0.36 | 0.58 | (2.16) | 2.53 | 0.45 | 1.24 |

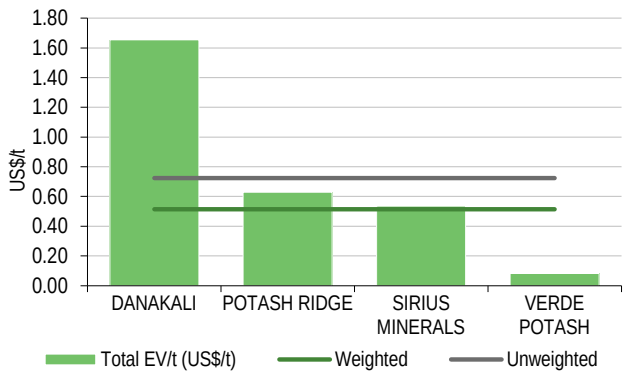
Source: Edison Investment Research

Sample sizes for each of the three sub-sectors are relatively small. In addition, neither the SOP nor the MOP nor brine samples had companies or projects with inferred resources only, complicating the differentiated analysis. As a result, and notwithstanding the indicated resource category premium (which remains relevant as it militates against companies seeking to promote resources to the measured category), it is likely that the market values these projects on the basis of total resources, rather than resources differentiated by resource categorisation. Even so, the MOP analysis was complicated by the loss of a number of companies from the sample as a result of either going private or being delisted or suspended.

Two features of the analysis are nevertheless immediately apparent:

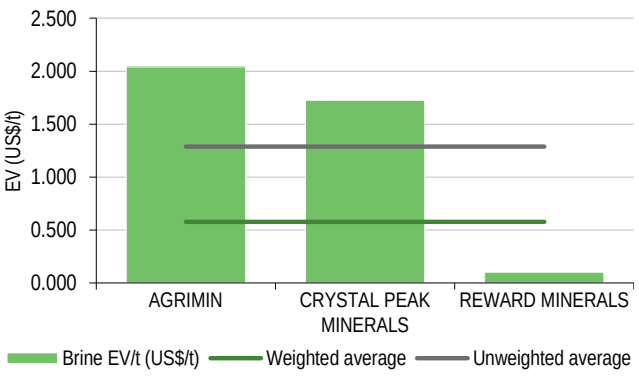
- Conventional SOP and MOP resources continue to exhibit a clear premium valuation for the indicated category of resources. Note that it is also possible that brines continue to exhibit this characteristic as well. It is only the assumption that the in-situ value of inferred resources equals that of indicated resources that renders the current result. In the event that inferred resources were deemed to have a value half of that of indicated resources (ie US$0.18/t), then discrete indicated resources would be worth US$2.07/t and measured resources US$1.46/t.
- In August 2016, the bottom of the range in-situ valuation for brine resources approximately corresponded to the top of the range in-situ valuation for conventional SOP resources. In 2017, this premium valuation appears to have dissipated to the extent that they might both reasonably be regarded as being part of the same population.

**Exhibit 62: Implied in-situ value of SOP resources (US$ per total tonne)**




Source: Edison Investment Research

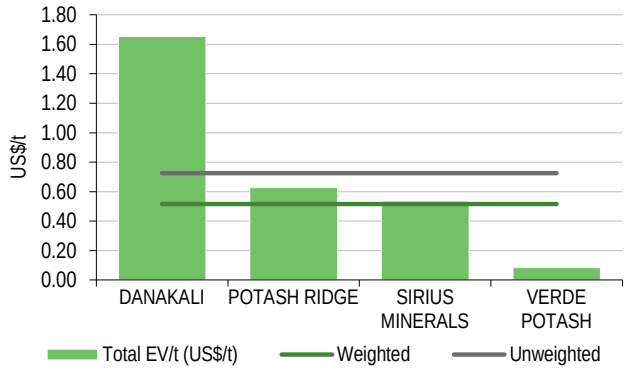
**Exhibit 63: Implied in-situ value of brine resources (US$ per total tonne)**




Source: Edison Investment Research

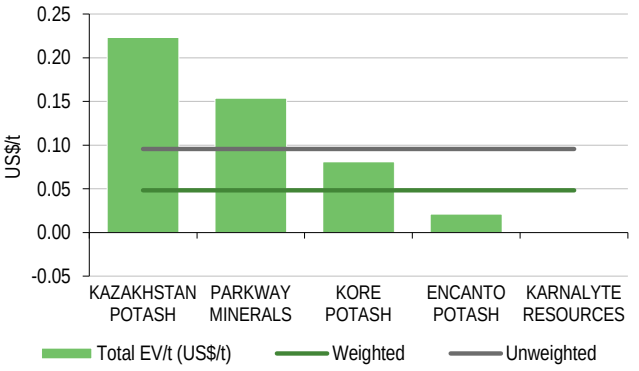
- On average, sulphate resources continue to attract a material premium valuation relative to muriate resources. On an individual level however, MOP explorers may achieve ratings comparable to SOP resources (note that a tonne of each contains roughly comparable numbers of potassium units).

**Exhibit 64: Implied in-situ value of SOP resources (US$ per total tonne)**




Source: Edison Investment Research

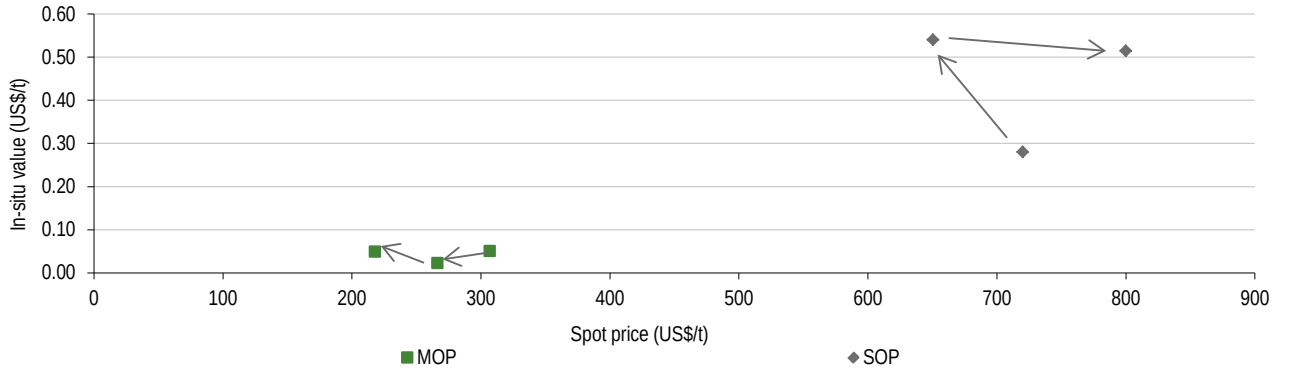
**Exhibit 65: Implied in-situ value of MOP resources (US$ per total tonne)**




Source: Edison Investment Research

Within the context of the commodity markets, it is notable that SOP resources broadly maintained their valuation despite being in a relatively buoyant market (arguably indicating that equity markets correctly discounted this rise in the commodity markets in 2015-16), while MOP resources increased in value despite being in a bear market (arguably indicating that they are now discounting a similar rise in the MOP price).

**Exhibit 66: In-situ MOP and SOP resource values (US$/t), 2015-17**




Source: Edison Investment Research

Note that all three sub-sections of the potash market could be interpreted as discounting a degree of future exploration success, but that, in each case, either the sample is too small or the correlation coefficient is too low from a mathematical perspective for this to be regarded as statistically significant.

## Copper

As with iron ore, copper has spent much of the last 12 months in a largely unexpected bull market. Within the context of Edison's analysis, this has manifested itself in a recovery in the value of in-situ resources in the indicated category at the expense of those in the measured category. As a result, for the first time, the implied value of measured copper resources stands at a discount to that of indicated resources.

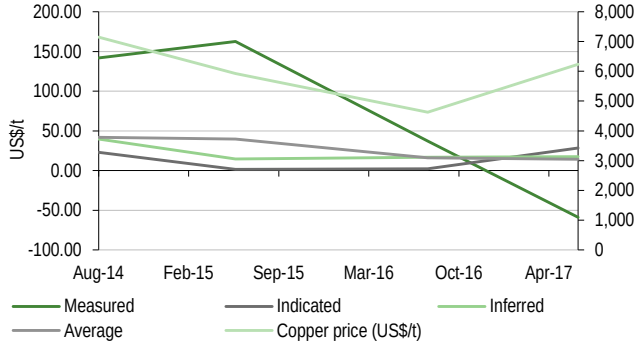
**Exhibit 67: Global average in-situ value of explorers' copper resources (US$/t)**

| | July 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ copper value (US$/t) | (59.00) | 28.23 | 17.58 | 14.35 | 36.97 | 2.23 | 16.59 | 15.94 | 162.66 | 1.57 | 14.57 | 39.82 |

Source: Edison Investment Research, Thomson Reuters Datastream

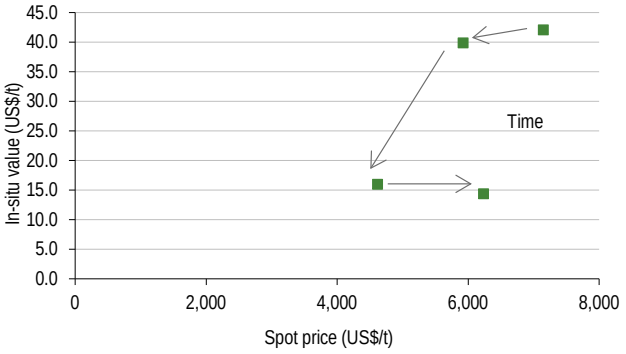
Surprisingly, in contrast to the buoyancy of the copper market, the value of average resources has declined, possibly indicating that the equity markets are not convinced by the recent strength in the metals markets:

**Exhibit 68: In-situ value of copper resources vs spot price of copper, by category, 2014-17**




Source: Edison Investment Research

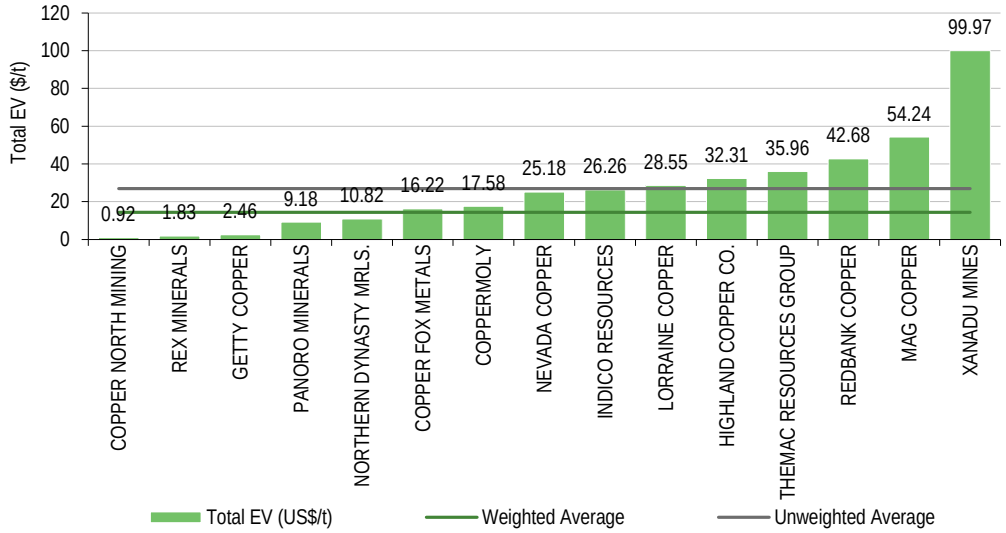
**Exhibit 69: In-situ value of explorers' copper resources vs spot price of copper, 2014-17**




Source: Edison Investment Research

*Prima facie*, this could be interpreted as evidence that the market values copper explorers with respect to total resources, rather than differentiated ones:

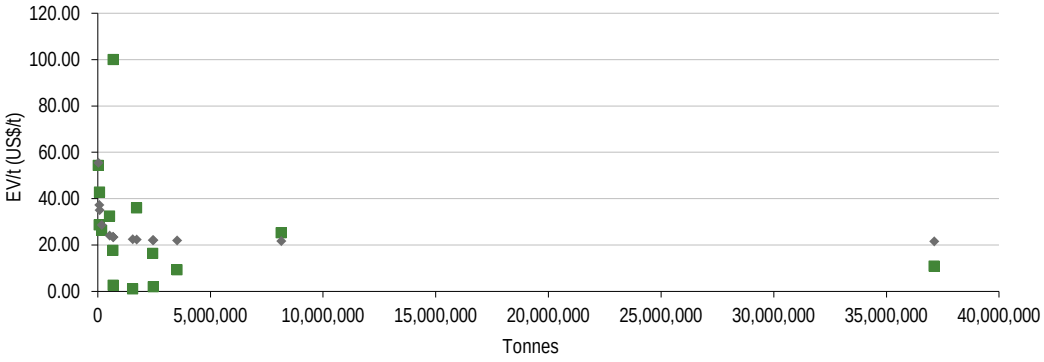
**Exhibit 70: Implied in-situ value of copper resources (US$ per total tonne)**




Source: Edison Investment Research

However, it is also noticeable that, within the context of the above population, those companies with the highest resource ratings are also those with below average contained resources. Once again, this suggests that the equity markets may be discounting a degree of future exploration success. While compelling visually, in mathematical terms, investors are cautioned that the presumed (inverse) correlation between resource size and multiple is not statistically significant at the 5% level for the size of the sample (ie there is more than a 5% chance that this correlation could have occurred by random chance):

**Exhibit 71: Graph of resource size (Mt) vs resource multiple (US$/t) for copper explorers**




Source: Edison Investment Research

## Zinc (lead)

Zinc is often discovered in association with lead. For the purposes of Edison's analysis, all lead co-existing in the resource was therefore converted into zinc equivalent (ZnE). At the time of the analysis, the price of zinc (US$2,871/t) was similar to the price of lead (US$2,367/t), such that the analysis could have been conducted the other way around to derive in-situ values for lead equivalent resources with similar, if not identical, results.

**Exhibit 72: Global average in-situ value of explorers' zinc equivalent resources (US$/t)**

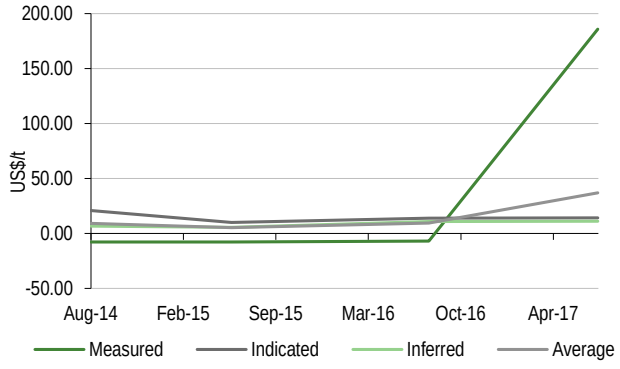
| | August 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ zinc value (US$/t) | 185.94 | 14.27 | 11.13 | 36.90 | (7.03) | 14.02 | 10.85 | 9.45 | (7.65) | 10.10 | 5.67 | 5.36 |

Source: Edison Investment Research, Thomson Reuters Datastream

Conditions in the zinc market have been robust over the course of the past 12 months. Nevertheless, two features of Edison's analysis are immediately discernible:

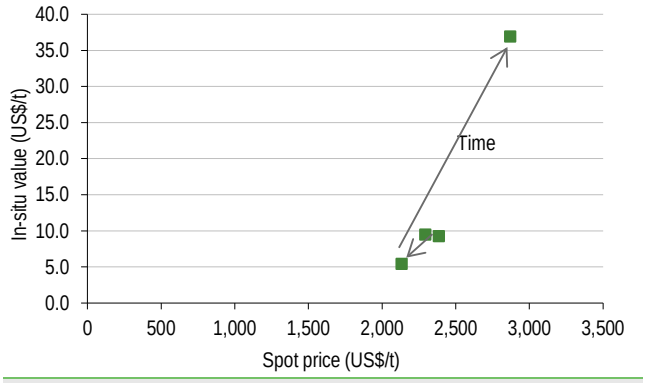
- There has been a disproportionate increase in the average value of in-situ zinc equivalent resources relative to the price of zinc.
- The vast majority of the increase has been confined to those companies with measured resources, rather than those with indicated and/or inferred resources.

**Exhibit 73: In-situ value of zinc equivalent resources vs spot price of zinc, by category, 2014-17**




Source: Edison Investment Research

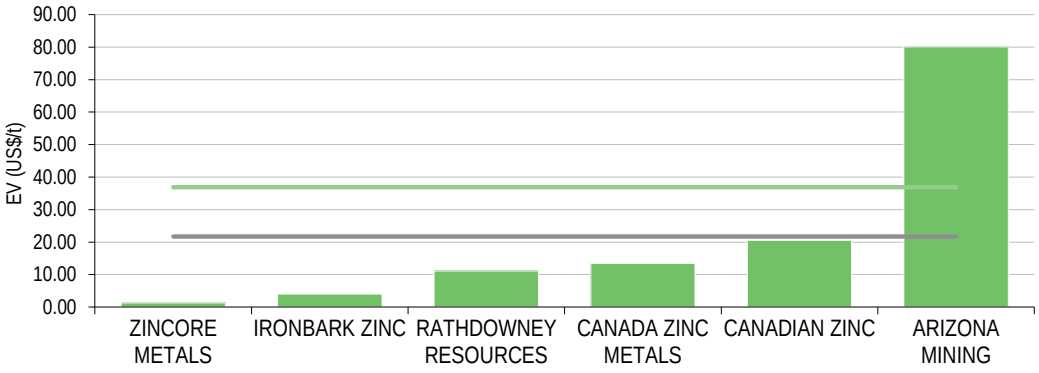
**Exhibit 74: In-situ value of zinc equivalent resources vs spot price of zinc, 2014-17**




Source: Edison Investment Research

The analysis of zinc in-situ resources was complicated by the fact that the size of the population was relatively small and that there was only one company with inferred resources only and only one company with inferred and indicated resources only. These companies nevertheless provided data points that were consistent with the broader analysis. Like a number of other metals and minerals however, zinc explorers may also be analysed with reference to total resources:

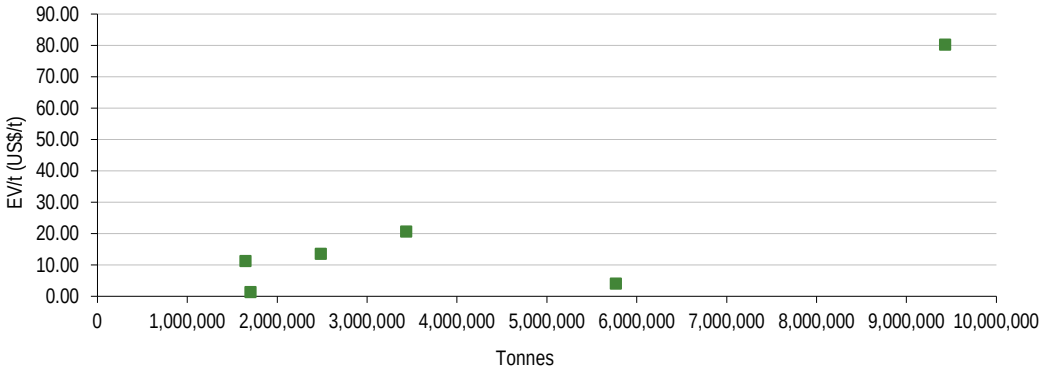
**Exhibit 75: Implied in-situ value of zinc equivalent resources (US$ per total tonne)**




Source: Edison Investment Research

Very unusually though, and in contrast to many other metals and minerals, rather than apparently discounting a degree of future exploration success, investors in zinc appear to be focused on the size and scale of the resource already delineated and, instead, afford proportionately higher valuations to larger potential projects:

**Exhibit 76: Graph of resource size (Mt) vs resource multiple (US$/t) for zinc explorers**




Source: Edison Investment Research

Notwithstanding the small sample size, the above graph nevertheless exhibits a very strong (Pearson product-moment coefficient of 0.83) and statistically significant positive correlation between resource size and multiple.

## Lithium

As with our nickel and potash analyses, Edison's lithium analysis has been sub-divided, with Western Australian companies with spodumene resources being distinguished from the balance of the sector.

**Exhibit 77: Global average in-situ value of explorers' lithium resources (US$/t)**

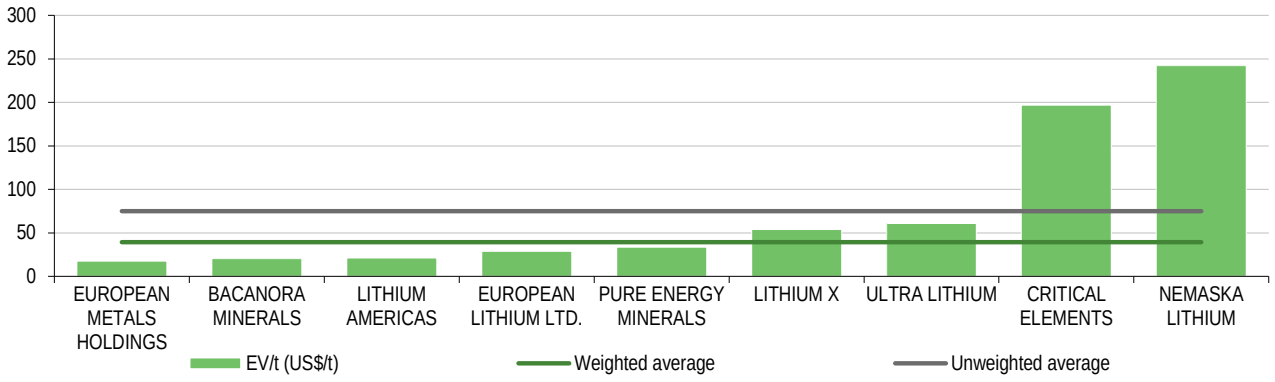
| US$/t | August 2017 | | | | August 2016 | | | |
|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ lithium value | (198.89) | 92.33 | 33.43 | 39.16 | 96.47 | 18.51 | 23.17 | 25.72 |
| Western Australian spodumene companies | (206.47) | 140.86 | 49.14 | 75.95 | N/M | 213.13 | 29.30 | 124.91 |

Source: Edison Investment Research, Thomson Reuters Datastream. Note that all lithium resources have been converted into lithium carbonate equivalent tonnes for the purposes of this analysis.

In contrast to August 2016, when the analysis was last conducted, it is notable that the premium rating of Western Australian spodumene explorers has narrowed markedly, compared to the broader sector. It is also apparent that there has been a shift in valuation in favour of early-stage, lower confidence resources (ie inferred and, especially, indicated resources) at the expense of measured ones. An illustration of both is perhaps provided by Pilbara Minerals (a Western Australian spodumene explorer), which in the summer of 2016 announced a 60% increase in the size of its total resource, including a maiden measured component, but its enterprise value was barely changed in August 2017 compared with a year earlier.

At the same time however, considered on an undifferentiated basis (below), there is continued evidence of a discounted valuation being accorded to clay and clay-like deposits (eg Bacanora and European Metal Holdings) and an average valuation being accorded to brines (eg Lithium X, Pure Energy and part-Lithium Americas). It is also notable that, on this basis, the two companies that are arguably the most advanced in terms of developing mining operations are also those that are statistical outliers in terms of their valuations (namely, Critical Elements and Nemaska Lithium).

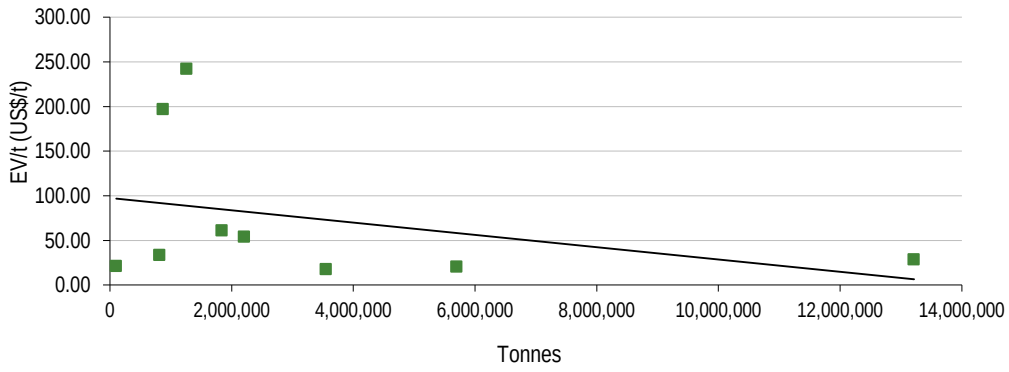
**Exhibit 78: Implied in-situ value of lithium resources (US$ per total tonne)**




Source: Edison Investment Research

In addition, there is also anecdotal (but definitely not statistically significant) evidence that the market appears to discount some degree of future exploration success – albeit, it may be that the relationship is linear, rather than inverse:

**Exhibit 79: Graph of resource size (t) vs resource multiple (US$/t) for lithium explorers**




Source: Edison Investment Research

## Graphite

After a large increase in 2015/16, graphite prices briefly dropped to their lowest point in years earlier in 2017, before recovering strongly in recent months as competing visions for the future jostled for primacy in the mind of the markets.

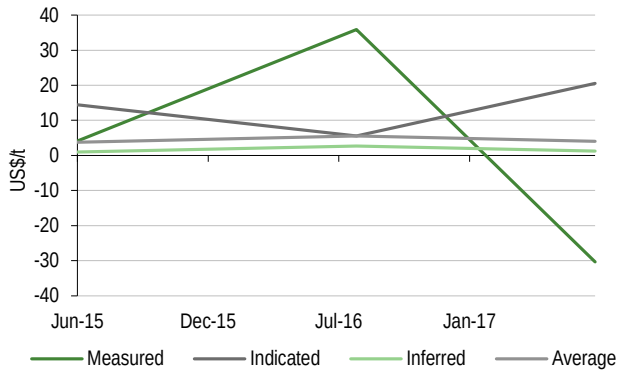
**Exhibit 80: Global average in-situ value of explorers' graphite resources (US$/t)**

| | August 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ zinc value (US$/t) | (30.31) | 20.51 | 1.29 | 4.02 | 36.10 | 11.38 | 2.01 | 6.42 | 4.13 | 14.43 | 0.97 | 3.79 |

Source: Edison Investment Research, Thomson Reuters Datastream

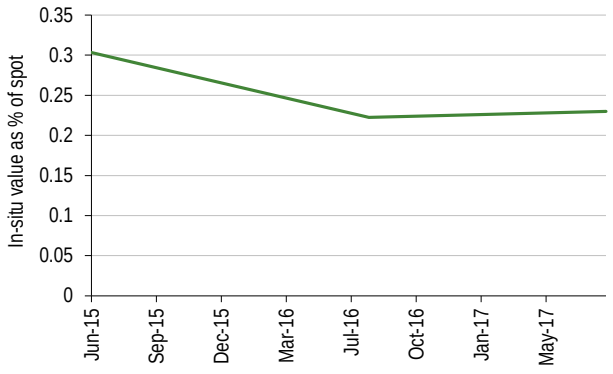
At the point at which Edison's analysis was conducted, graphite prices were still below those prevailing at the time of our previous analysis in August 2016. While the overall in-situ value of resources declined in the face of a decline in the graphite price, it remained (effectively) constant in percentage terms. Moreover, it was noticeable that the majority of the decline in value could be attributed to those companies with measured resources, while the values of those with earlier stage inferred and indicated resources held up relatively well:

**Exhibit 81: In-situ value of graphite resources vs spot price of graphite, by category, 2015-17**




Source: Edison Investment Research

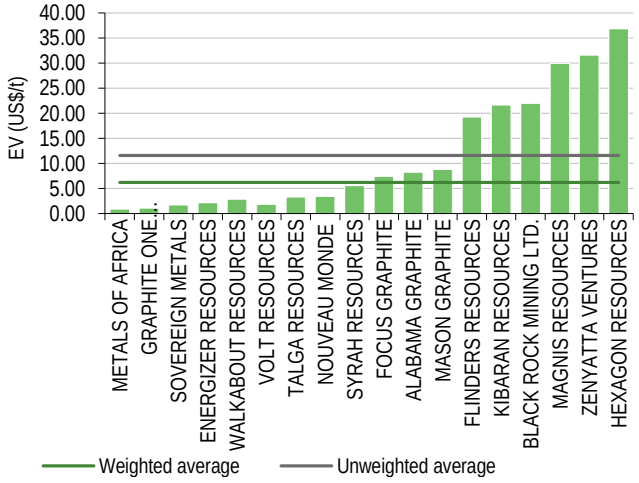
**Exhibit 82: In-situ value of total graphite resources as percentage of spot price of graphite, 2015-17**




Source: Edison Investment Research

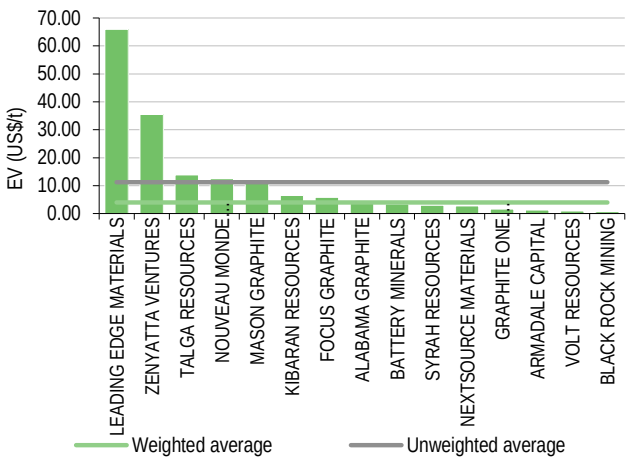
As in August 2016, within the context of the undifferentiated analysis, there appear to be two distinct groups within the population (Mason & above and Kibaran & below), although this pattern is somewhat obscured by the ratings afforded to Leading Edge Materials and Zenyatta (which are clear statistical outliers with multiples more than one standard deviation above the mean).

**Exhibit 83: Implied in-situ value of graphite resources (US$ per total tonne), August 2016**




Source: Edison Investment Research. Note: Leading Edge Materials formed in August 2016 via the merger of Tasman Metals with Flinders Resources.

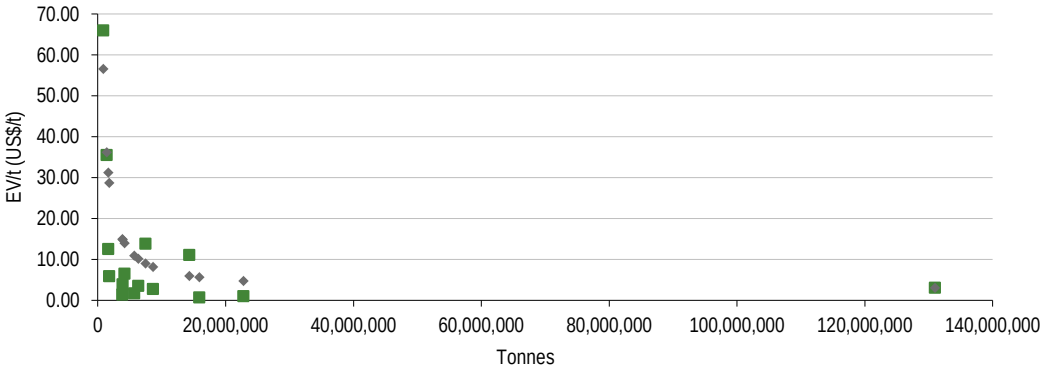
**Exhibit 84: Implied in-situ value of graphite resources (US$ per total tonne), August 2017**




Source: Edison Investment Research

However, this distinction may be justified by the fact that Leading Edge and Zenyatta, in particular, have relatively small resources and an analysis of resource size vs resource multiple indicates that there is strongly statistically significant evidence of the discounting of future resource discoveries by the markets:

**Exhibit 85: Graph of resource size (t) vs resource multiple (US$/t) for graphite explorers**




Source: Edison Investment Research

However, while an analysis over the whole population reveals a strongly statistically significant inverse relationship between resource multiple and resource size, a best-fit line based on this data produces a negative implied resource multiple for the company with the largest resource (the data point to the far right Exhibit 85). As a result, this line is in fact derived only for the companies with the top five ratings (for which the correlation is even stronger). For investors wishing to accept the veracity of this line, it implies that there are two distinct sub-groups within the population:

- In the first, the markets appear to be discounting a degree of future exploration success up to about 15Mt of contained graphitic carbon (the upper portion of Exhibit 85).
- In the second, the markets appear to be assuming no further exploration success regardless of the size of the existing deposit (hence the existence of small, lowly rated deposits to the bottom left of Exhibit 85), which have an average resource multiple of US$2.98/t contained carbon.

## Tungsten

As with a number of other metals, the sample of dedicated tungsten explorers is small. It was also complicated by the fact that there was only one company with indicated and inferred resources only and (unusually) only one company with all three categories of resources.

**Exhibit 86: Global average in-situ value of explorers' vanadium resources (US$/t)**

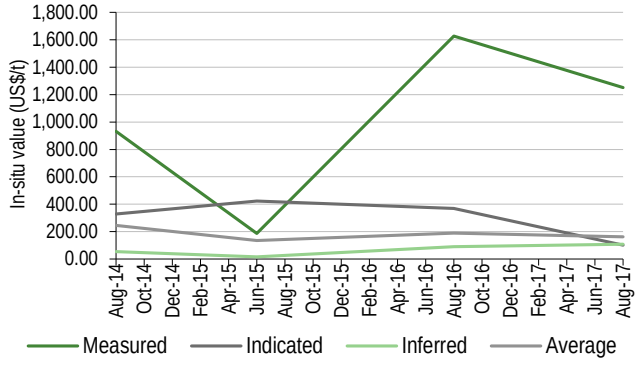
| | August 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ tungsten value | 1,251.59 | 100.87 | 108.47 | 162.90 | 1,627.68 | 368.47 | 89.59 | 189.60 | 186.10 | 424.03 | 15.15 | 135.17 |

Source: Edison Investment Research, Thomson Reuters Datastream

Nevertheless, a number of features of the analysis are immediately apparent:

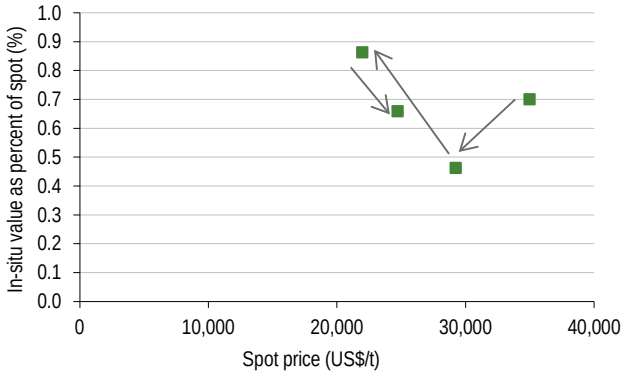
- A decline (albeit modest) in the in-situ value of an average tungsten resource tonne, despite an increase in the price of ammonium paratungstate (APT).
- A relatively resilient performance of the in-situ value of inferred resources in contrast to a weak performance of the in-situ value of indicated resources, such that the two are now broadly comparable.
- A continuation of the large premium enjoyed by measured resources compared to either indicated or inferred resources.

**Exhibit 87: In-situ value of tungsten resources differentiated by category, 2014-17**




Source: Edison Investment Research

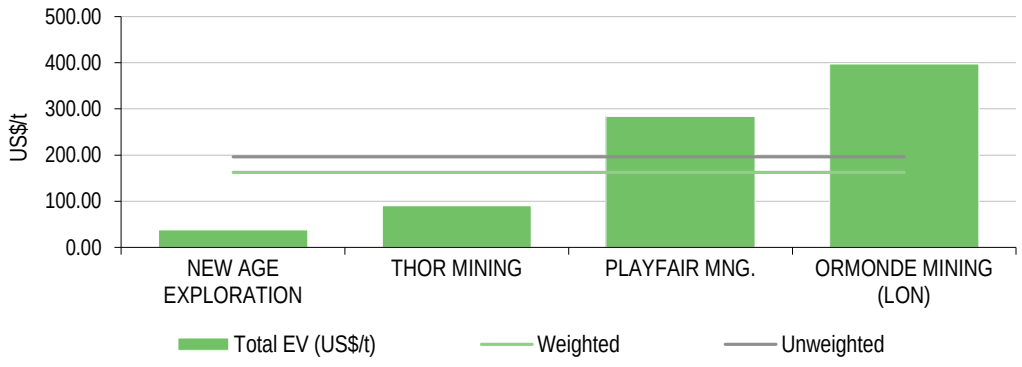
**Exhibit 88: In-situ value of tungsten resources as percentage of the spot price of APT, 2014-17**




Source: Edison Investment Research

By contrast, analysis of the tungsten explorers by total resource yielded two distinct groupings within the population, being a highly rated group (Playfair and Ormonde) and a more lowly rated one (Thor Mining and New Age Exploration):

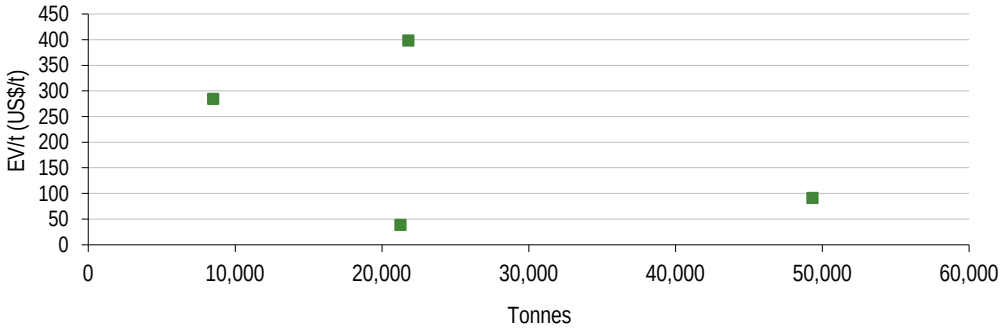
**Exhibit 89: Implied in-situ value of tungsten resources (US$ per total tonne)**




Source: Edison Investment Research

Although there is anecdotal evidence of the discounting of future resource discoveries by investors in tungsten juniors, in statistical terms and given the small sample size, the empirical data is weak (ie not statistically significant) and the relationship (eg inverse or linear) difficult or impossible to determine.

**Exhibit 90: Graph of resource size (t) vs resource multiple (US$/t) for tungsten explorers**




Source: Edison Investment Research

## Vanadium

After a two-year period in which the price of vanadium (in the form of vanadium pentoxide) fell by 30.5% and the value of in-situ resources fell by 96.1%, both staged a material recovery in 2016/17.

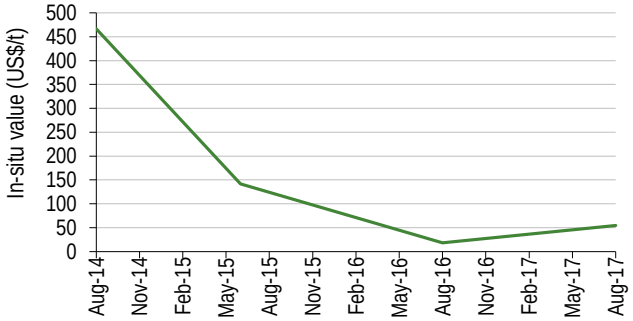
**Exhibit 91: Global average in-situ value of explorers' vanadium resources (US$/t)**

| | August 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ vanadium value (US$/t) | 205.49 | 56.40 | 21.37 | 54.40 | 135.15 | (6.73) | 9.64 | 18.01 | 1,103.03 | 30.57 | 6.64 | 141.40 |

Source: Edison Investment Research, Thomson Reuters Datastream

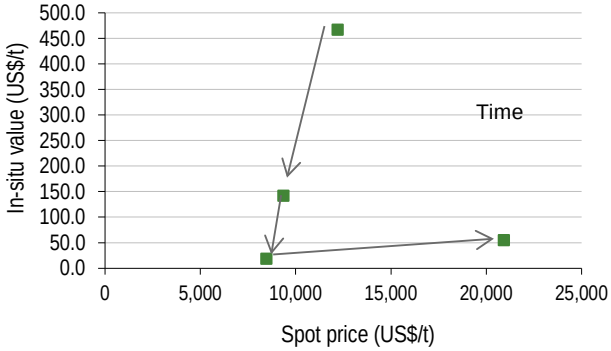
Of note is the fact that there were material increases in value across all three categories of resources and also that the average value increased as a percentage of the spot price of $V_2O_5$ (from 0.21% to 0.26%), although it remains consistent – or even cheap – relative to other metals and minerals (see Exhibits 110 & 111).

**Exhibit 92: In-situ value of vanadium resources, 2014-17**




Source: Edison Investment Research

**Exhibit 93: In-situ value of vanadium resources vs spot price of vanadium, 2014-17**



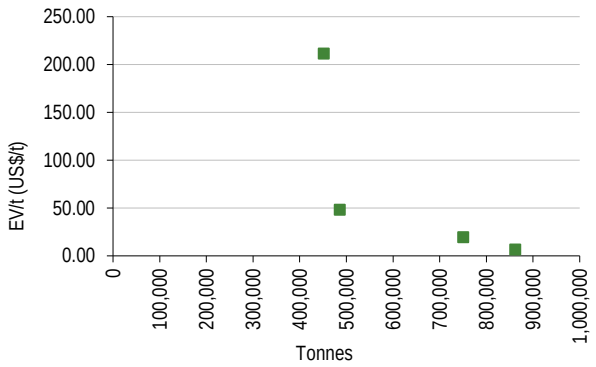

Source: Edison Investment Research

In the case of vanadium juniors, part of the reason for the de-rating between 2014 and 2016 was the re-focusing of erstwhile vanadium explorers (in particular, the relatively highly rated Syrah and Energizer Resources) away from vanadium to other metals and minerals (eg graphite), while new entrants to the market were afforded markedly lower ratings than their predecessors.

Edison's analysis in 2017 was complicated by the small population of vanadium explorers and also by the loss of Bushveld Minerals from the peer group as a result of its acquisition of Vametco, which thereby promoted it from the ranks of explorers into the ranks of producers. As a result of Bushveld's exclusion, there were no companies remaining with indicated and inferred resources only, by which to derive a valuation for indicated resources. As a result, a valuation for indicated resources was chosen that was mid-way between its possible maximum (on a par with measured resources) and its possible minimum (on a par with inferred resources).

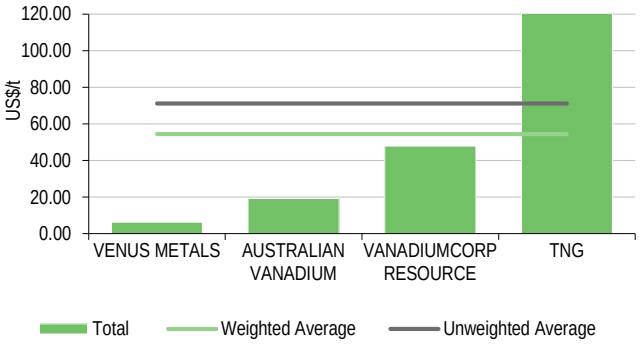
Note that there is some evidence of the market discounting future resource discoveries, although this must be considered as non-statistically significant given the number of data points in the population:

**Exhibit 94: Graph of resource size (t) vs resource multiple (US$/t) for vanadium explorers**




Source: Edison Investment Research

**Exhibit 95: Implied in-situ value of vanadium resources (US$ per total tonne)**




Source: Edison Investment Research

## Metallurgical coal

The analysis of metallurgical coal resource values was complicated by the fact that a) the population of metallurgical coal explorers is small and b) there were no companies or projects that had either inferred resources only (which account for 63% of all resources in the sample) or indicated and inferred resources only. As a result, in 2017, only an average value per average tonne of in-situ resource could be derived from the available data.

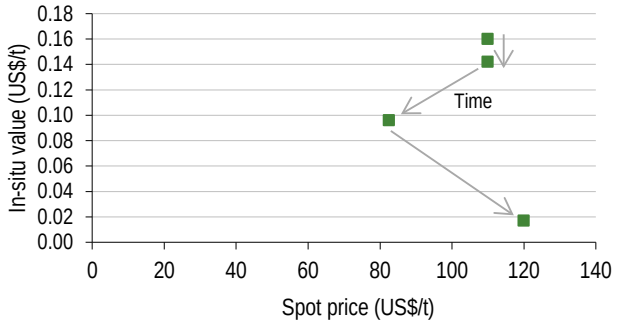
**Exhibit 96: Global average in-situ value of explorers' metallurgical coal resources (US$/t)**

| | August 2017 | | | | August 2016 | | | | June 2015 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total | Measured | Indicated | Inferred | Total |
| In-situ metallurgical coal value (US$/t) | No data | No data | No data | 0.017 | 5.87 | 0.04 | 0.01 | 0.10 | (3.01) | 0.71 | 0.27 | 0.16 |

Source: Edison Investment Research, Thomson Reuters Datastream

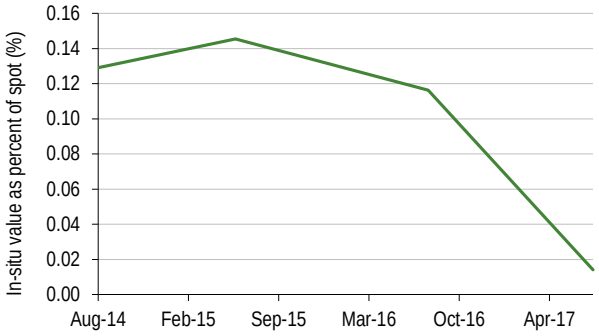
The main feature of Edison's analysis of the value of metallurgical coal resources is the continued (and, in this case, material) de-rating of the average value of resources, both in nominal terms and as a percentage of the spot price of metallurgical coal, notwithstanding a recovery in the price of metallurgical coal itself.

**Exhibit 97: In-situ value of metallurgical coal resources vs spot price, 2014-17**




Source: Edison Investment Research

**Exhibit 98: In-situ value of metallurgical coal resources as a percentage of the spot price, 2014-17**




Source: Edison Investment Research

Note that, in 2016, the analysis was performed before the recent, extraordinary jump in the price of metallurgical coal in September 2016 as a result of China's reforms to domestic industry. Consequently, its de-rating in that year should be seen as a function of the prior bear market for metallurgical coal.

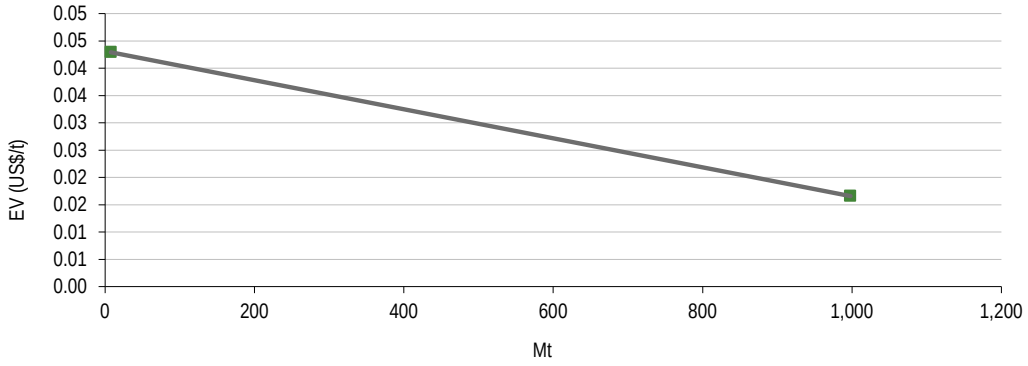
Given the variability in the differentiated values of measured, indicated and inferred metallurgical coal values over time as well as between each other, it seems likely that the market conceives of metallurgical coal deposits in terms of total, rather than differentiated resources:

**Exhibit 99: Implied in-situ value of metallurgical coal resources (US$ per total tonne)**


Source: Edison Investment Research

Anecdotally, it may be inferred that there is some evidence of investors' discounting future discoveries of metallurgical coal resources. Given that there are only two data points in the sample however, there is a necessarily strong (perfect) correlation between resource size and rating. Self-evidently however, this correlation (while numerically strong) cannot be said to be statistically significant, which is similar to the situation in 2016. Moreover, it is similarly impossible to determine whether any relationship is inverse or linear.

**Exhibit 100: Graph of resource size (t) vs resource multiple (US$/t) for metallurgical coal explorers**




Source: Edison Investment Research

## Thermal coal

Thermal coal resources have never yielded themselves to a differentiated analysis and have never been presented in this way. In keeping with recent experience therefore, results here are presented solely in terms of companies' total resources:

**Exhibit 101: Global average in-situ value of explorers' thermal coal resources (US$/t)**

| | August 2017 | August 2016 | June 2015 | August 2014 |
|---|---|---|---|---|
| In-situ thermal coal value (US$/t) | 0.017 | 0.013 | 0.020 | 0.007 |

Source: Edison Investment Research, Thomson Reuters Datastream

In marked contrast to conditions among metallurgical coal producers, thermal coal juniors appear to have experienced concurrent recoveries in both the value of in-situ resources and the product itself:

**Exhibit 102: Implied in-situ value of thermal coal resources (US$ per total tonne)**

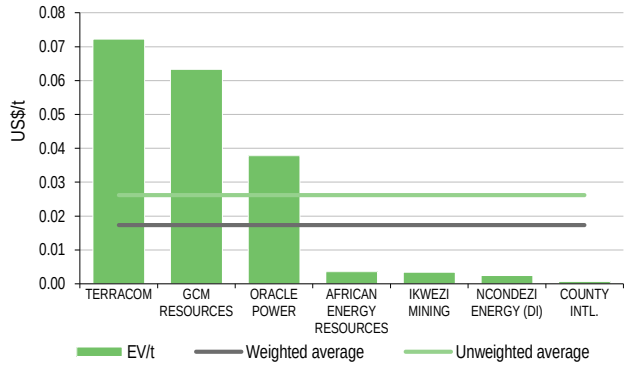
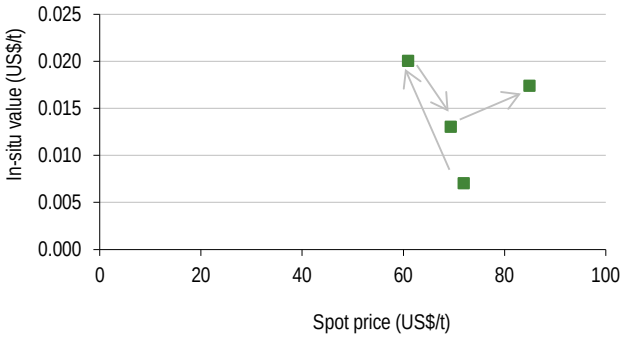


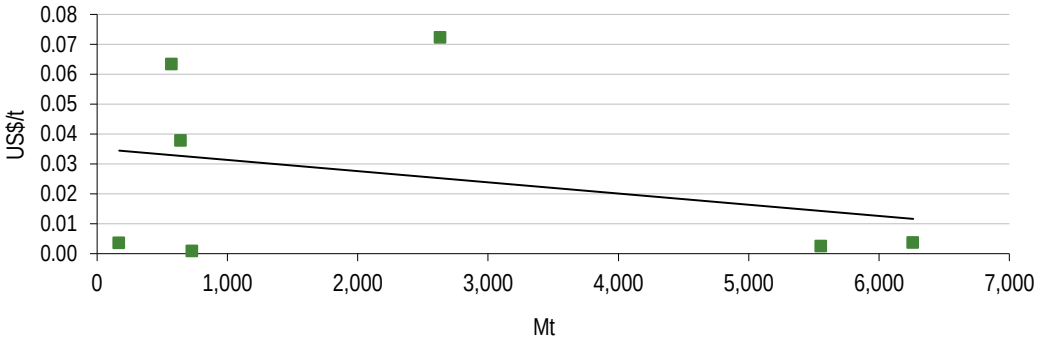

**Exhibit 103: In-situ value of thermal coal resources vs spot price, 2014-17**




Source: Edison Investment Research

Finally, there is also weak (but definitely not statistically significant) evidence that the market discounts some degree of future exploration success for thermal coal companies – albeit, it may be that the relationship is linear, rather than inverse:

**Exhibit 104: Graph of resource size (t) vs resource multiple (US$/t) for thermal coal explorers**




Source: Edison Investment Research

## Bauxite

As with thermal coal, bauxite resources do not yield themselves readily to a differentiated analysis.

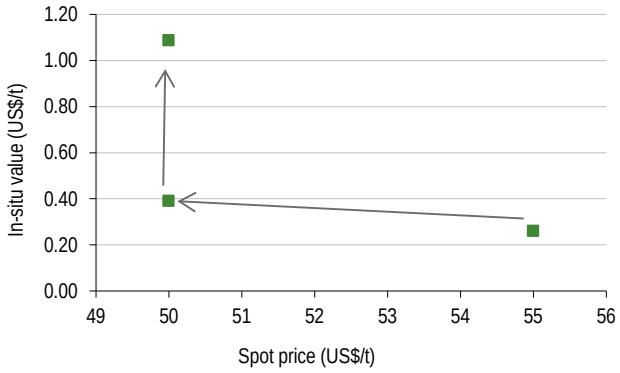
**Exhibit 105: Global average in-situ value of explorers' bauxite resources (US$/t)**

| | August 2017 | August 2016 | June 2015 |
|---|---|---|---|
| In-situ bauxite value (US$/t) | 1.09 | 0.39 | 0.26 |

Source: Edison Investment Research, Thomson Reuters Datastream

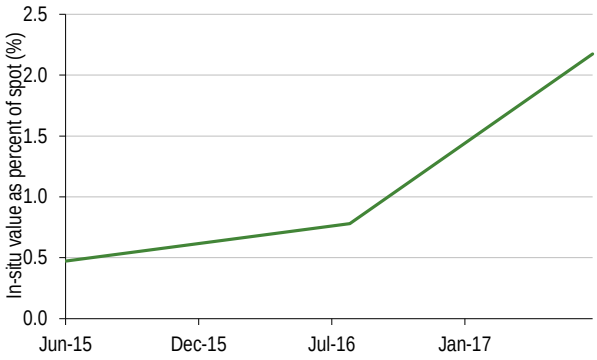
Of note, however, is the increase in the value of in-situ bauxite resources at a time when the bauxite price has remained largely flat, leading to bauxite's in-situ value as a percentage of the spot price of bauxite rising to 2.17% vs 0.77% in 2016 (cf 0.08% for iron ore, 0.02% for thermal coal, 0.04% for metallurgical coal and 0.02-0.07% for potash):

**Exhibit 106: In-situ value of bauxite resources vs spot price, 2015-17**




Source: Edison Investment Research

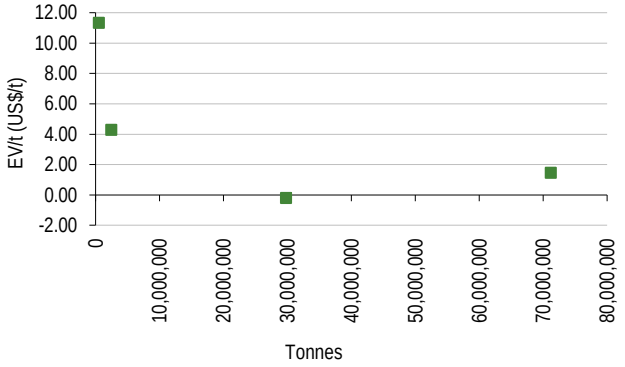
**Exhibit 107: In-situ value of bauxite resources as percentage of spot price, 2015-17**




Source: Edison Investment Research

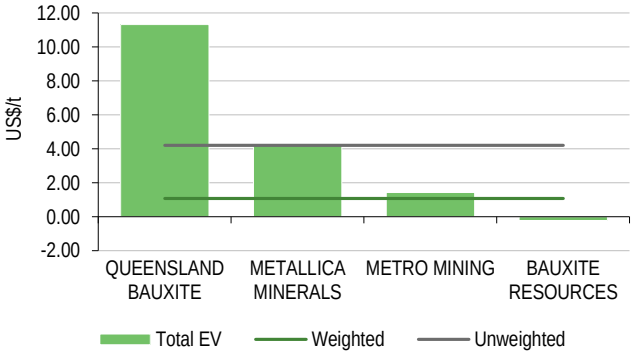
As with nickel explorers however, while visually quite compelling, the number of data points in the bauxite population is too small, in mathematical terms, for the correlation between resource size and resource multiple to be regarded as statistically significant at the 5% level.

**Exhibit 108: Graph of resource size (t) vs resource multiple (US$/t) for bauxite explorers**




Source: Edison Investment Research

**Exhibit 109: Implied in-situ value of bauxite resources (US$ per total tonne)**

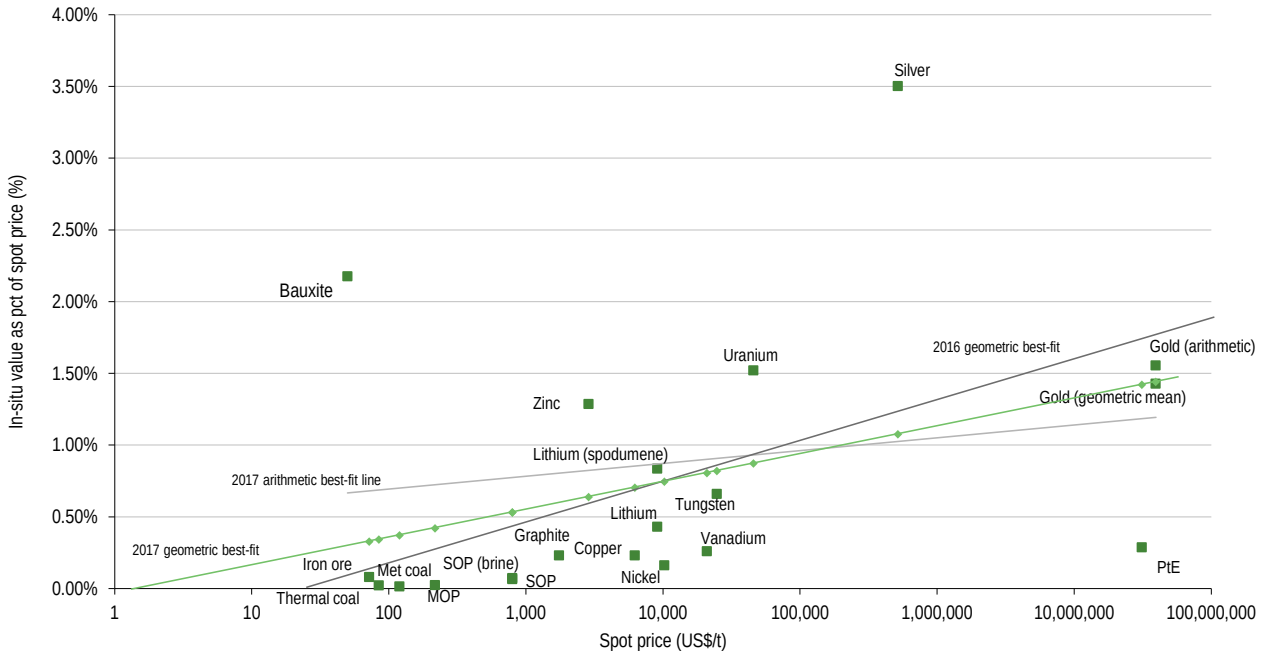



Source: Edison Investment Research

## Undifferentiated analysis

In addition to our differentiated analysis, Edison has also performed undifferentiated analyses on 18 metals and minerals. In this case, the analysis has been performed with respect to the spot price of the relevant metal or mineral at the time of the analysis. For example, the geometric average in-situ gold ounce at the time of the differentiated analysis was US$17.54/oz (vs US$16.84/oz in 2016), which equated to 1.43% (vs 1.28%) of the price of gold at the time that the analysis was performed. That is to say, the value of an in-situ ounce was 1.43% of the value of a refined ounce. The chart below shows this analysis performed for the other 17 metals and minerals covered in this report as well. Note that all metal prices have been converted into US dollars per tonne in order that they may be shown on the same scale (for example, gold at the time was US$1,228.70/oz, or US$39,503,934/t). As such, the x-axis scale – being the spot price of the metal or mineral in question – may be considered a proxy for economic scarcity.

**Exhibit 110: In-situ resource values vs spot prices, selected metals and minerals**




Source: Edison Investment Research

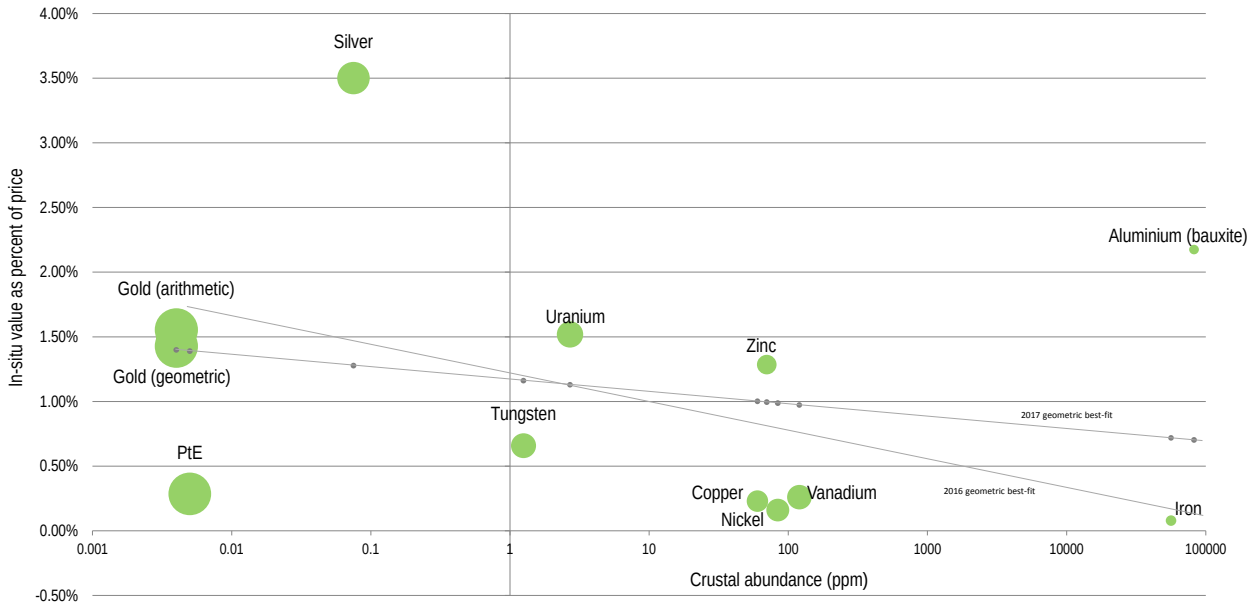
A number of features of the analysis are immediately apparent:

- Within the sample, there is a statistically significant correlation between the logarithm of spot prices and in-situ values. Note that the correlation is only just statistically significant. Moreover, while it is statistically significant between the logarithm of prices and in-situ values expressed as a percentage of spot, the correlation is not statistically significant between prices and in-situ values (expressed as a percentage of spot).
- In-situ values for the majority of metals and minerals are 'below trend', given their spot prices.
- Excluding the arithmetic mean for gold, only five metals and minerals have in-situ values 'above trend' given their spot prices; of these two might be regarded as relatively 'new' in terms of their existence on publicly traded stock markets – namely bauxite and lithium (spodumene). The traditional three are silver, uranium and zinc.
- The best fit line of the points in 2017 is markedly more flat lying than the equivalent line in 2016, such that companies with deposits of metals or minerals with a spot price of US$1.43/t or less should not expect to be afforded any in-situ value for their resources. However, this compares to an equivalent price last year of US$18.82/t or less. Much of this flattening may be

attributed to relatively large increases in the values of bauxite, zinc and uranium resources relative to their spot prices (see Exhibit 113).

The same data may be represented, explicitly relating in-situ values to crustal abundance (subject to availability), as follows:

**Exhibit 111: In-situ resource values vs crustal abundance, selected metals and minerals**

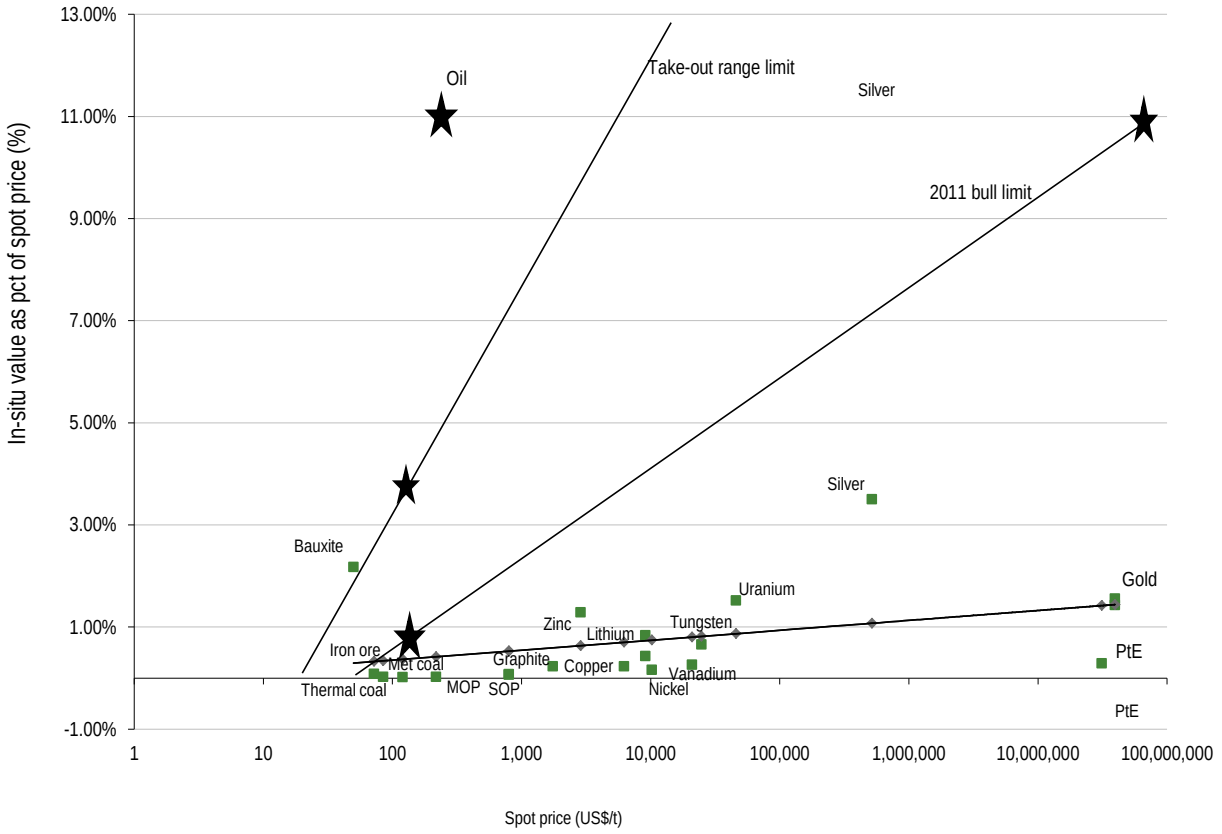



Source: Edison Investment Research. Note: Bubble size represents Log (price US$/t).

Note that the depressed position of the point relating to platinum (PtE) may be explained by its bimodal distribution in the earth's crust (ie it being found specifically in the Bushveld complex in South Africa and Norilsk in Russia), compared to gold and silver, which might be considered to be 'universally' rare.

Nevertheless, in-situ values remain a long way from those that were typical during the bull market in 2011-12 and also those at which premium acquisitions occurred, when transactions as high as 35% of the spot price of gold and 3.9% of the spot price of iron ore were recorded (see Gold: The value of gold and other metals, published in February 2015):

**Exhibit 112: In-situ resource values vs spot prices, within historical range, selected metals and minerals**




Source: Edison Investment Research

Aside from the lower limit line of best fit, two additional lines are shown. These are identical to those depicted in our last two reports on the subject (Gold: The value of gold and other metals, published in February 2015 and Mining overview: Normalisation augers well for exploration, published in October 2016). They represent the estimated position of the line of best fit at the top of the bull market in 2011 and the upper limit of the range of in-situ values achieved in corporate transactions in the last cycle – represented by the acquisition of African Iron by Exxaro in January 2012 at a price equivalent to a resource multiple of US$5.70/t Fe (3.9% of the spot price of iron ore) and Newmont's acquisition of Fronteer at an in-situ resource multiple of US$475/oz Au, or 32-35% of the spot price of gold (excluding the Pilot Gold spin-out), in February 2011. Note that not all points on the chart have been labelled owing to space constraints; however, they are identical to those depicted in Exhibit 110.

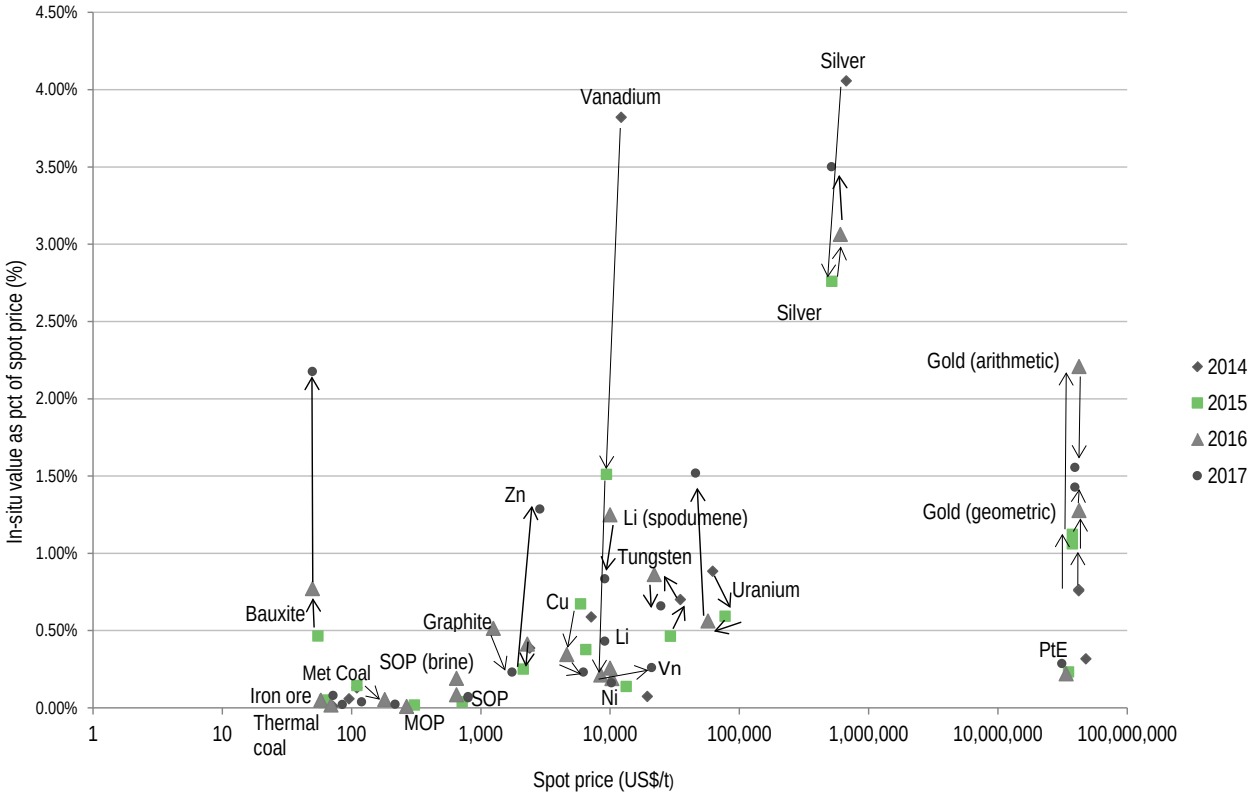
For reference, a point has been added to the graph to show the position of the oil industry. The point has been added after consultation with Edison's oil & gas team and is based upon an oil price of US$330/t (US$45/bbl) and typical in-ground valuations (IGVs) of US$5/bbl. It is immediately apparent that oil companies trade at exceptional in-situ valuations with respect to mining companies, albeit some of this may be attributable to their relatively higher unit costs of discovery and their relatively lower unit costs of development.

Of the 17 distinct metals and minerals profiled, the prices of seven (gold, uranium, silver, platinum, nickel, MOP and graphite) declined since Edison's last note on the subject (Mining overview: Normalisation augers well for exploration, published in October 2016). In the same timeframe, the prices of nine (iron ore, SOP, copper, zinc, tungsten, vanadium, lithium, metallurgical coal and thermal coal) have risen, while one (bauxite) is ostensibly unchanged.

Similarly, the in-situ values of eight metals and minerals (namely copper, nickel, metallurgical coal, SOP, SOP brines, tungsten, spodumene lithium and graphite) have declined since October 2016 in both nominal and percentage terms, while the in-situ values of 10 (gold, uranium, iron ore, platinum, thermal coal, MOP, zinc, vanadium, lithium and bauxite) have increased. However, not all of the metals and minerals that saw price increases also saw in-situ values increase and vice versa. Exceptions were:

- In-situ value declined in both nominal and percentage terms, despite prices rising: copper, metallurgical coal, SOP, SOP brines, spodumene lithium and tungsten.
- In-situ value increased in both nominal and percentage terms, despite prices falling: gold, uranium, platinum, MOP and bauxite.

**Exhibit 113: In-situ resource values vs spot prices, selected metals and minerals, 2014-17**




Source: Edison Investment Research

Several aspects of the graph are noteworthy:

- The sharp increases in in-situ value as a percentage of spot price of bauxite, uranium and zinc.
- The continued recovery in the in-situ value of silver resources as a percentage of spot price and its continued premium valuation within the sample.
- The convergence of the arithmetic and geometric means for gold – suggesting that the sample size of gold companies may be large enough to be regarded as representative.
- The increase in the in-situ value of vanadium (expressed as a percentage of spot) coincident with a strong bull market in the price of vanadium (in the form of vanadium pentoxide, $V_2O_5$) – albeit to a level that is below that expected (1.0%) given its in-situ value last year expressed as a percentage of the spot price (0.21%) and the subsequent movement in the spot price.

A summary of the various characteristic of each metal and mineral profiled by Edison is as follows:

**Exhibit 114: In-situ resource valuation characteristics, by metal/mineral**

| | Gold | | | U | Ag | Iron ore | PGMs | Ni | SOP | MOP | SOP (brine) | Cu | Zn | Li | Graphite | W | Vn | Met coal | Thermal coal | Bauxite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | AIM | TSX | ASX | | | | | | | | | | | | | | | | | |
| Market conditions | | Bear | | Bear | Bear | Bull | Bear | Neutral/ Bear | Bull | Bear | Bull | Bull | Bull | Neutral /Bear | Bear | Bull | Bull | Bull | Bull | Neutral |
| Amenable to differentiated resource valuation | ✓ | ✓ | ✓ | | | ✓ | | ✓ | | | ✓ | | ✓ | | | ✓ | ✓ | | | |
| Amenable to valuation with respect to total resource | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Measured resource discount | | | | | ✓ | | ✓ | | ✓ | ✓ | | ✓ | | ✓ | ✓ | | | | ✓ | ✓ |
| Indicated resource premium | | | | | | | | | | | | | | | | | | | | ✓ |
| Indicated resource discount | | ✓ | | ✓ | | | | | | | | | | | | | | | | |
| Evidence of discounting for size | ✓ SS | | | ✓ | ✓ SS | ✓ SS | Weak (linear?) | Weak NSS | Weak NSS | Weak NSS | Strong* | Weak NSS | | Weak (linear?) | ✓ SS | Weak NSS | Weak NSS | Strong* | Weak NSS | Strong* |
| No evidence of size discounting | | ✓ | | | | | | | | | | | ✓ | | | | | | | |
| Size premium | | | ✓ | | | | | | | | | | ✓ | | | | | | | |
| Small sample size | | | | | | | ✓ | | ✓ | ✓ | ✓ | | ✓ | | | ✓ | ✓ | ✓ | | ✓ |

Source: Edison Investment Research. Note: SS = statistically significant at the 5% level; NSS = not statistically significant at the 5% level. *Insufficient sample size to be regarded as statistically significant.

In summary:

- Metals amenable to a differentiated resource analysis tend to be rare (eg gold) or relatively specialised (eg nickel, SOP brine, zinc, tungsten and vanadium). The exception appears to be iron ore and it may be that it is a simple coincidence that iron ore assets currently yield to a differentiated, as opposed to undifferentiated, valuation of in-situ resources.
- The majority of metals and minerals now demonstrate some form of discounting of future discoveries. Historically, these have tended to be metals and minerals of a 'bulk' nature (eg iron ore, thermal coal, metallurgical coal, muriate of potash, etc) plus uranium. However, this grouping has now been joined by gold (listed in London) and silver and potentially PGMs, SOP brines, tungsten, vanadium and bauxite.
- Very many metals and minerals exhibit either an indicated resources premium or a measured resource discount, indicating that investment with the intention of promoting indicated resources to the measured category is likely to be value destroying. These include silver, PGMs, conventional SOP, MOP, copper, lithium, graphite, metallurgical coal, thermal coal and bauxite. They do not (or are unlikely to) include gold, uranium, iron ore, nickel, SOP brine, zinc, tungsten and vanadium.
- Two metals exhibit a positive correlation between resource size and in-situ valuation – ie the larger the resource, the higher the in-situ rating – namely gold assets listed on the ASX and zinc.

# NonSuch Gold

## The physical limitations created by financial boundaries

In the report Gold:– New benchmarks for old, published in November 2012, Edison created a notional mining company, which it called NonSuch Gold Ltd. The characteristics of this company were designed to approximate those to which many junior gold mining companies aspire and Edison was then able to use the in-situ resource valuations calculated earlier in this report in conjunction with its benchmark discount rates for companies at different stages of development (eg see Gold: US$2070 by 2020, published on 20 November 2013) in order to value this company at every year of its existence, from initial funding to the end of the life of its operations, and to then to interrogate that valuation with respect to both outside influences and internal development strategies.

In general, in conducting our analysis in 2017, we concluded that the investment environment remains one of general risk averseness with a 32% increase in the number of jurisdictions that might be deemed un-investible for an otherwise average project and a 10% increase in the grade below which a project might similarly be deemed un-investible by equity markets (all other things being equal).

### Creating, valuing and manipulating NonSuch Gold

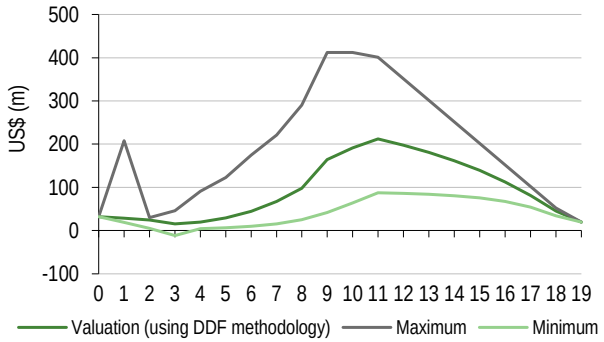
The characteristics of NonSuch Gold were designed to approximate those to which many junior gold mining companies aspire, namely:

- The delineation of a 1.336Moz resource, 74.9% of which (being the measured and indicated portion of the resources) was then converted into reserves and mined at a rate of 100koz per year for 10 years. The company was deemed to be listed in London and it was financed in three rounds of equity funding in year 0 (initial capital for exploration), year 4 (to complete scoping, pre-feasibility and bankable feasibility studies) and year 7 (for development).
- After raising its initial finance, NonSuch Gold then delineated an inferred resource in year 1, an indicated and inferred resource in year 2 (in a 50:50 ratio) and a measured, indicated and inferred resource in year 3 (in a 21:54:25 measured:indicated:inferred ratio). It then raised additional equity funds in year 4 in order to commission a scoping study, a pre-feasibility study and a bankable feasibility study in years 4, 5 and 6, respectively. In year 7 it completed a final round of equity, in addition to debt, funding, such that its leverage (debt/(debt+equity)) peaked at 50%, and embarked on the first of three years of capital expenditure. Production ramp-up began in year 8 and full production was achieved in year 9. Full production was maintained from years 9 to 18 inclusive (ie 10 years). Working capital was then released in year 19 when the company reverted to being an exploration entity (its only assets being cash and an inferred resource).
- In years 0 to 3, the company was valued according to the in-situ value of its resources (differentiated by category, assuming a London listing) plus cash. Note that the London-listed assumption affects only years 1 to 3; Canada- and Australia-listed explorers would have the profiles shown in Exhibit 23 on page 18. In years 4 to 18, NonSuch Gold is valued according to the discounted dividend flow method at the mean discount rates (as interpreted by Edison) defined and set out in the report Gold: US$2070 by 2020 plus the (undiscounted) value of the residual inferred resource. Working capital is released in year 19, such that the company reverts to being an exploration entity with cash and an inferred resource only.

- Unit costs of discovery are those calculated by BDO and Edison and set out in Edison's report Gold: Valuation benchmarks are obsolete, published in January 2010, namely US$7.16 per inferred ounce, US$10.50 per indicated ounce and US$36.82 per measured ounce.
- Of the company's 1.336Moz resource, 1.0Moz are in the measured and indicated categories, which are assumed to have a 100% conversion ratio into reserves.
- Study costs are estimated at 1.5% of capex (ie US$1.5m in total) and are deemed to be cumulative, ie scoping study costs contribute towards pre-feasibility study costs, and pre-feasibility study costs towards bankable feasibility study costs, etc.
- Central, general and administrative costs amount to US$4m per year until the company enters production, when they increase to US$7.5m per year.
- Equity fundings are conducted at the implied value of the equity, given the state of advancement of the project, ie no discount to the prevailing share price is assumed.
- Capex amounts to US$100 per annual ounce of production, ie US$100m, or US$100 per reserve ounce.
- Debt peaks at the end of year 8 (ie the year before full production is achieved), when gearing (ie debt/equity) reaches 100% and leverage (debt/(debt+equity)) reaches 50%.
- The cost of debt is set at 11%; return on cash deposits at 0.5%.
- A gross cash profit margin of US$725/oz has been assumed during the mine's producing phase, which may be rationalised in terms of a gold price of US$1,350/oz and total cash costs of US$625/oz.
- Profits are taxed at 28% (after depreciation); there is no write-off for past exploration expenses.

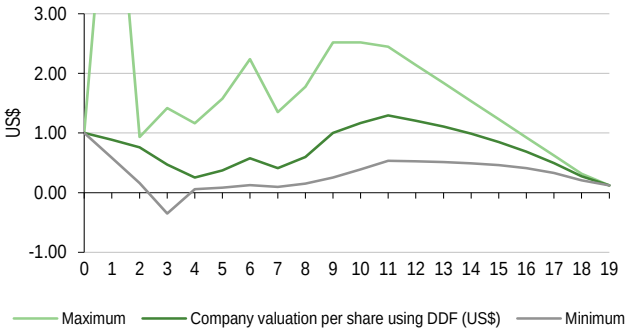
On the basis of the assumptions set out above, the undiscounted value of the dividends paid out to shareholders is US$409.9m, comprising cash flow from operations (US$459.8m), minus total life-of-mine capex (US$121.7m), plus total equity funding (US$89.0m) minus terminal cash balances (US$17.2m). Graphs of the resultant value of NonSuch Gold and its share price, as calculated by Edison, are provided below. Note that full financials for the company are provided on page 42 of Gold: US$2070 by 2020, published in November 2013.

**Exhibit 115: NonSuch Gold value by year, US$m**




Source: Edison Investment Research

**Exhibit 116: NonSuch Gold share price by year, US$**



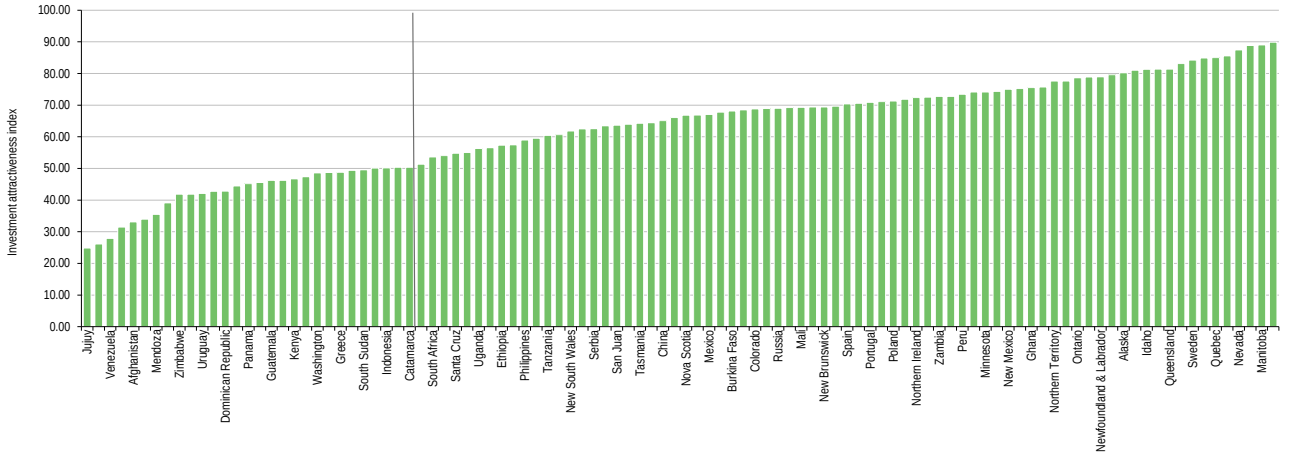

Source: Edison Investment Research

Of note is the spike in maximum potential valuation in year 1. This is also a feature of the Australian and Canadian markets, albeit the spike in maximum potential Canadian market valuations occurs in year 3, rather than year 1. Nevertheless, it is an indication that significant valuation premia are achievable by gold exploration juniors at some point in the exploration profile of a project, regardless of the centre of listing.

However (as discussed in last year's report, entitled Mining overview: Normalisation augers well for exploration, published in October 2016), the company must negotiate a critical funding point in year 7. If the project is not deemed sufficiently viable to generate a positive return on invested funds, it will not be financed. This occurs if a 40.3% discount rate is applied to future dividends, within a

range from 8.0% to 62.0% (see Gold: US$2070 by 2020, published in November 2013) or a 43.0% discount rate is applied to cash flows. If political risk is then deemed to be measured by the Fraser Institute's Investment Attractiveness Index and the lowest-risk mining investment destination (Saskatchewan in 2016, with a score of 89.91) is assumed to correspond to a minimum discount rate of 8.0% and the highest-risk mining investment destination (Jujuy in Argentina, with a score of 24.83) is assumed to correspond to a maximum discount rate of 62.0%, then a discount rate of 40.3%, as applied to potential future dividends, occurs at a Fraser index score of 50.98 – between Catamarca (Argentina) and Bulgaria:

**Exhibit 117: Fraser Institute Investment Attractiveness Index, 2016 survey**



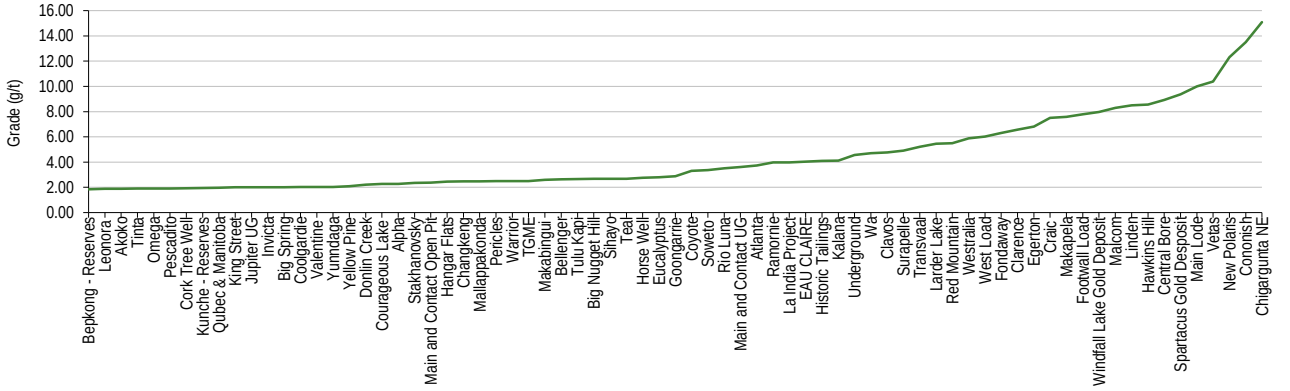

Source: Fraser Institute, Edison Investment Research

Some 29 jurisdictions appear below the implied investible cut-off line for 'average' projects, compared to 22 in 2016. Of the original 22 jurisdictions, 14 (Neuquen, Venezuela, Chubut, La Rioja, Mendoza, Zimbabwe, Uruguay, Honduras, Guatemala, Kenya, Bolivia, Greece, Ecuador and Catamarca) remain, two (St Cruz and French Guiana) have been promoted 'above' the line, six (Solomon Islands, Guinea, Rio Negro, Kyrgyzstan, Niger and New Caledonia) have been discontinued from the series and there are 14 new entrants, namely Jujuy, Afghanistan, India, Mozambique, Dominican Republic, Myanmar, Panama, Sierra Leone, Hungary, Washington state, Mongolia, South Sudan, France and Indonesia.

If one considers a mining project or company to attract five principal risks – namely sovereign, geological, engineering, metallurgical and management – then, all other things being equal, an 'average' gold mining project (ie one with average geological, engineering, metallurgical and management risk) will struggle to attract finance in jurisdictions with a lower Investment Attractiveness rating than Bulgaria.

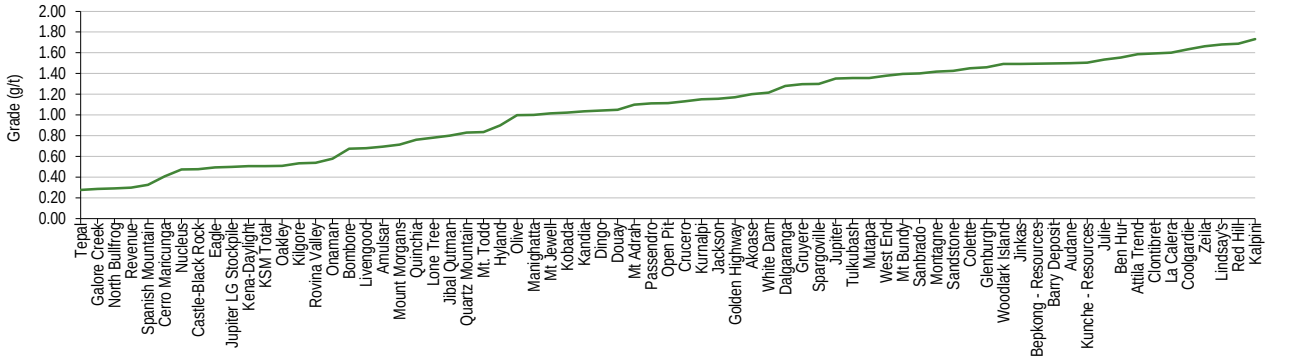
A similar process may be undertaken for any of the other four main risks in the event that a suitable, quantitative measure of each can be identified. For example, grade could be used as a measure of geological risk. Self-evidently, this is not a perfect measure and, in reality, other factors such as continuity, orientation and profile also need to be considered. Nevertheless, the results of such a process are instructive. Once again, taking the sample of projects considered in Edison's in-situ analysis elsewhere in this report, if the lowest-grade project is assumed to correspond to the highest geological risk and the highest-grade project is assumed to correspond to the lowest geological risk, then a risk-adjusted discount rate of 40.3% is obtained for a project with a grade of 1.82g/t (cf 1.66g/t in 2016), within a range as follows:

**Exhibit 118: Edison sample gold projects by resource grade above 1.82g/t (g/t)**




Source: Edison Investment Research

**Exhibit 119: Edison sample gold projects by resource grade below 1.82g/t (g/t)**




Source: Edison Investment Research

Hence, a gold company with a project that is in all other respects 'average' (ie average engineering, metallurgical, management and sovereign risk – which, using the Fraser Institute survey, corresponds approximately to Serbia, Brazil, Turkey, Papua New Guinea, Tasmania, Greenland, China, Namibia and/or Mexico with Investment Attractiveness ratings between 60.67 and 62.06) is likely to find that project similarly difficult to finance unless it has a grade of at least 1.82g/t (cf 1.66g/t in 2016). Note that four deposits within Edison's sample have grades between 1.66g/t and 1.82g/t.

## Price/NPV: A key transition

For the first time in this series of reports, Edison has performed a price to project NPV analysis for those companies for which data exists. The analysis covers gold, silver, uranium, copper and zinc junior, and three types of study, namely preliminary economic assessments (PEAs), pre-feasibility studies (PFSs) and bankable feasibility studies (BFSs).

The intention of the analysis is to determine how project economics affect company valuations. In doing so, Edison formed a view as to what an 'average' project looks like but, significantly, was able to conclude that, owing to the skewed distribution of valuations relative to project economics, statistical means are of very little use in predicting company valuations in the real world. Moreover, we observed that it is not always the companies with the high IRRs that have the high valuations. In interrogating this aspect of company valuations, we were able to quantify, rank and track over time the effect of a number of variables in determining a company's valuation, including grade, IRR, jurisdiction and project size. By a process of elimination, we were then able to make some observations about the importance of management in conferring upon companies exceptional, or outsize, valuations relative to their physical and financial characteristics. Finally, we were able to compare the results of this method of company valuation with those derived using differentiated market derived discount rates for companies at different stages of development (first introduced in our report, Gold: New benchmarks for old, published in November 2012, and subsequently updated) with pleasing results.

Broken down by principal commodity, the sample of companies studied in our EV/NPV analysis was as follows:

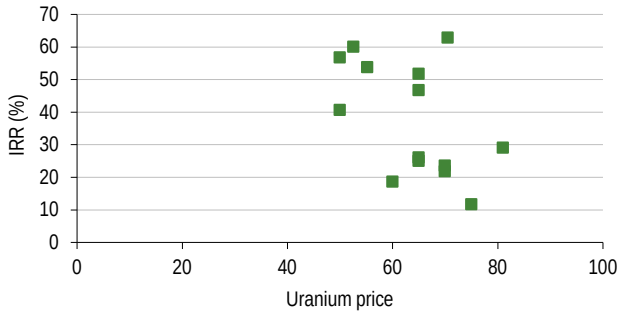
**Exhibit 120: Price: NPV analysis sample size, by commodity**

| Commodity | Number of companies | Percentage of total (%) |
|---|---|---|
| Gold | 33 | 52 |
| Uranium | 14 | 22 |
| Copper | 8 | 13 |
| Silver | 7 | 11 |
| Zinc | 1 | 2 |
| Total | 63 | 100 |

Source: Edison Investment Research

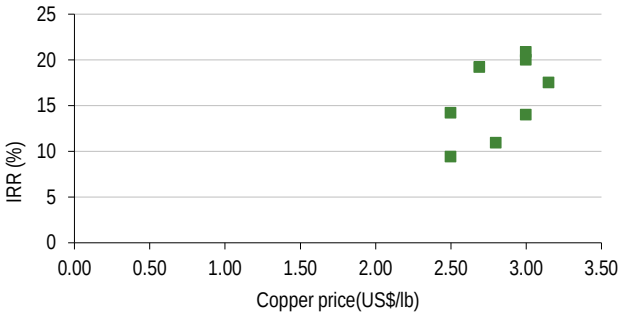
In the first instance, the analysis is conceived to compare company values with the published results of the study performed on their projects. As a result, there is inevitably some variance in the commodity prices at which some of the studies were conducted and also the discount rates used. Where possible, Edison has attempted to source data to make comparisons as direct as possible. For the gold sub-sample therefore, study results were used that were based upon a gold price as near as possible to US$1,250/oz and a discount rate as near as possible to 8%. Nevertheless, there were inevitably outliers, although, interestingly, these tended not to be outliers in terms of either their NPVs or their IRRs. In addition, without converting projects into gold equivalent, it is extremely difficult to source data in the uranium and copper sub-sectors that was directly comparable to using a gold price of US$1,250/oz. In the event, uranium prices ranged from US$50.00-81.00/lb and copper prices ranged from US$2.50-3.15/lb (US$5,513-6,946/t). Some impression of the degree to which commodity pricing affects project economics may be gleaned from comparing project commodity price with pre-tax IRR for the two sub-sectors:

**Exhibit 121: Graph of project uranium price (US$/lb) vs project IRR (%) for sample of uranium developers**




Source: Edison Investment Research, company sources

**Exhibit 122: Graph of project copper price (US$/lb) vs project IRR (%) for sample of copper developers**




Source: Edison Investment Research, company sources

Of note is the positive (but not statistically significant) correlation between price and IRR for the copper developers compared with a negative (and statistically significant) correlation for the uranium developers. Readers are invited to provide their own explanations for the causality behind such observations. In the opinion of the author:

- The positive correlation between price and IRR for the copper sample appears logical.
- For the uranium sample, it could be inferred that there is a correlation between costs and prices and that high costs are therefore coincident with high prices. Alternatively, the high range may be a consequence of a lack of pricing clarity between producers and consumers and/or that a high price may be necessary for certain deposits to give the impression of commerciality.

While the copper prices used in the studies are now close to, or even conservative, compared with the current spot price of copper (US$3.15/lb or US$6,965/t at the time of writing), it is worth noting that the uranium prices typically used in project studies are at a very material premium compared to the current spot price of US$20.30/lb and are more comparable to some long-term contract prices. Within the context of the following analysis, readers are invited to make such adjustments with respect to pricing as they feel is appropriate under the circumstances.

## Sample notes

Of the 63 companies for which project data was collated, three had more than one project in development. In this case, project NPVs were aggregated and IRRs were derived by a weighted average of the individual projects' IRRs, according to NPV attributable to the parent. Three companies had projects for which no IRR number was reported. Within this context, the range of project NPVs and IRRs within the sample was as follows:

**Exhibit 123: Project NPV and IRR sample, range and averages**

| | IRRs (%) | NPVs (US$m) |
|---|---|---|
| Maximum | 404.0 | 4,800.0 |
| Mean | 43.2 | 433.1 |
| Minimum | 1.0 | -552.0 |

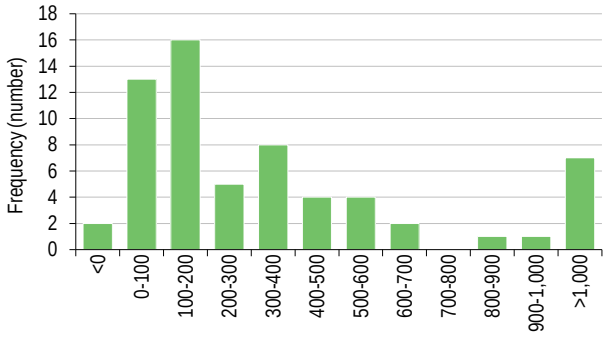
Source: Edison Investment Research, company sources

On first impression, therefore, the average project has an NPV of US$43.2m and an IRR of 43.2%. However, even a brief comparison of the position of the mean with respect to both the maximum and minimum values indicates that the sample follows a non-normal distribution, with the result that modal values (which may be more relevant to companies and investors) may be some way away from mean values.

## Sample NPVs

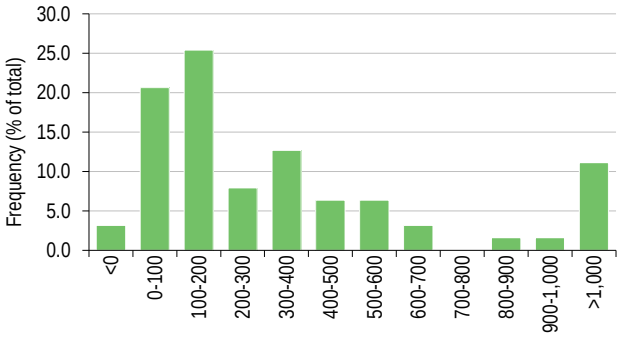
A histogram of the frequency of project NPVs, broken down into US$100m increments, by number and by percentage of the total, is as follows:

**Exhibit 124: Histogram of companies' aggregate project NPVs (US$m), number**




Source: Edison Investment Research, company sources

**Exhibit 125: Histogram of companies' aggregate project NPVs (US$m), percentage of the total**




Source: Edison Investment Research, company sources

Readers' attention is drawn to the disproportionate sizes of the intervals to the extreme left (<0) and right (>1,000) of the histograms. Also of note is the absence of project NPVs in the range US$700-800m and the seemingly depressed number in the range US$200-300m.

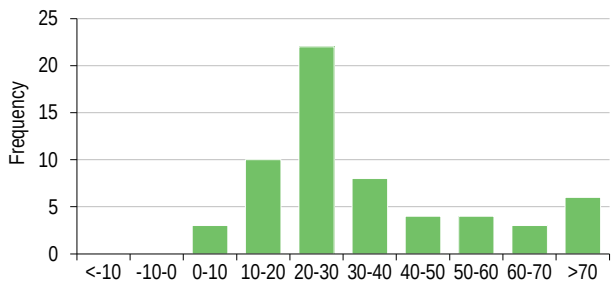
In the author's opinion, the data is consistent with three possible interpretations:

- A single population with a unimodal distribution, skewed right, with the depressed US$200-300m interval accounted for by an insufficiently large data sample.
- Two populations (one of smaller projects with a mode in the US$100-200m interval and one of larger projects with a mode in the US$300-400m interval), giving a bimodal distribution, skewed right.
- Three populations (smaller projects, medium projects and large projects), giving a tri-modal distribution, skewed right.

## Sample IRRs

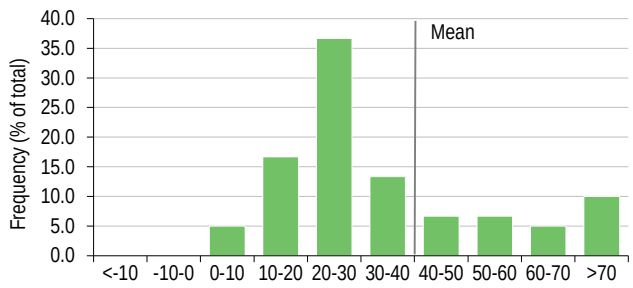
While the distribution of NPVs is open to a number of interpretations, the distribution of IRRs is strongly indicative of a unimodal, single population:

**Exhibit 126: Histogram of companies' average project IRRs (%), number**




Source: Edison Investment Research, company sources

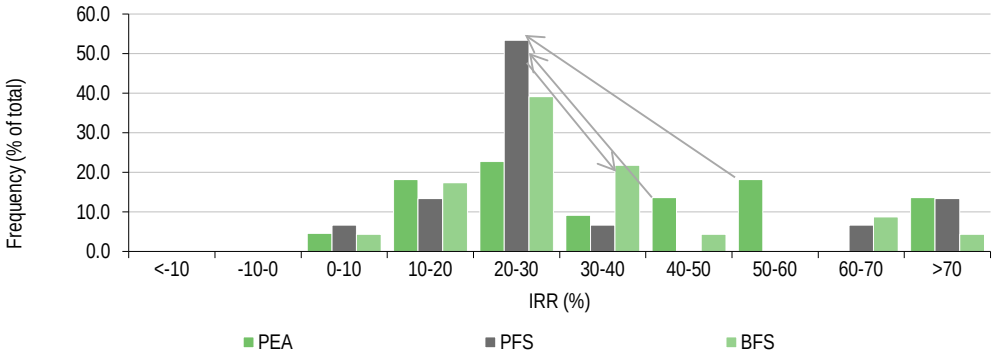
**Exhibit 127: Histogram of companies' weighted average project IRRs (%), percentage of the total**




Source: Edison Investment Research, company sources

Nevertheless, a more nuanced perspective become apparent when the various different types of study are considered:

**Exhibit 128: Histogram of companies' average project IRRs, by study type (percentage of the total)**




Source: Edison Investment Research, company sources. Note: Arrows reflect Edison interpretation of likely project IRR evolution with project development (see text below).

Assuming that project IRRs are comparable across the three different types of studies then of note are the following:

- The disproportionately high frequency of PEAs with IRRs in the range 40-60%, relative to PFSs or BFSs and the consequent multi-modal nature of the frequency distribution.
- The disproportionately high frequency of PFSs with IRRs in the range 20-30%, relative to PEAs or BFSs.
- The disproportionately high frequency of BFSs with IRRs in the range 30-40%, relative to PEAs or BFSs.

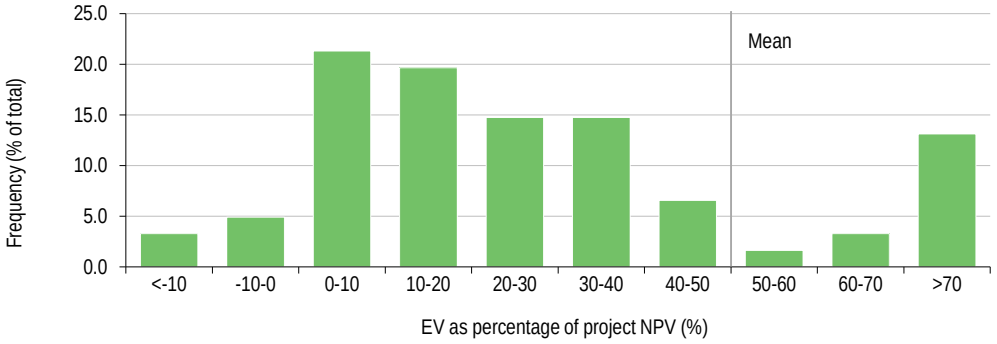
In the opinion of the author, these observations are likely to be explained by the lower level of confidence in costs that are inherent in many PEAs, which are typically desktop studies, based on industry average data. As a result, these may understate costs and result in higher project IRRs. As a project then progresses to PFS level, these costs are recalibrated (often by external consultants) to take account of specific project characteristics (often, apparently, upwards), resulting in IRRs that are c 25% lower than their equivalent PEA number (see arrows in Exhibit 128). As the projects then progress to BFS level, these costs then become finessed downwards as managements, often with the cooperation of consultants, seek to make the project as economically attractive as possible to external, third-party providers of finance, which results in project IRRs c 10% higher than their equivalent PFS numbers.

By contrast, projects with exceptional IRRs (>70%) at PEA stage appear to maintain these at PFS stage, but then see them finessed lower, into the range 50-60%, at BFS stage.

## Relating company valuations to project economics

In assessing valuations relative to project economics, the key measurement used by Edison is a company's enterprise value (EV) in US dollars expressed as a percentage of its project's attributable NPV (similarly in US dollars).Within Edison's sample, this measurement exhibits the following distribution, with a mean of 52.4%, within a range from -13.1% to 428.3%:

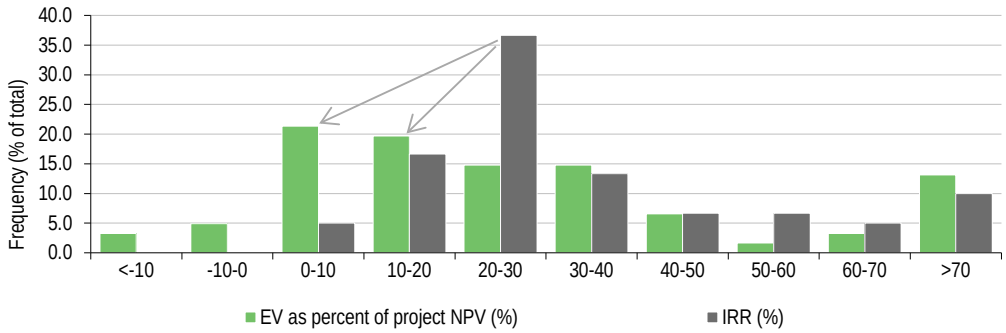
**Exhibit 129: Company EV expressed as a percentage of attributable project NPV (%)**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources. Note: Bar denoting >70 ranges up to 428%.

Immediately apparent from this graph is the very skewed position of the mean relative to the mode of the sample and the greater degree of skew compared with the histogram depicting project IRRs (Exhibit 127). Comparing the two yields the following result:

**Exhibit 130: Company EV as percent of attributable project NPV (%) and project IRR (%) histograms**



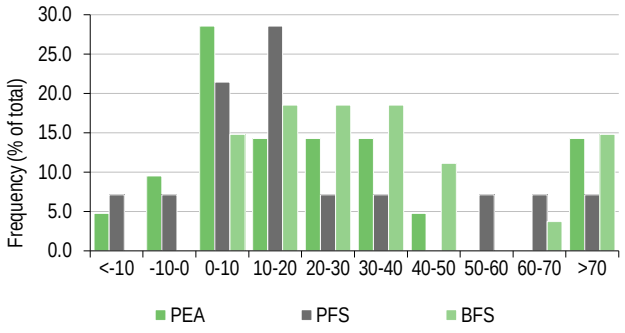

Source: Edison Investment Research, Thomson Reuters Datastream, company sources. Note: See text below for explanation of arrows; bar denoting >70 ranges up to 428% for EV/NPV (%) and up to 404% for IRR (%).

At first glance, it is tempting to make two conclusions:

- That, for companies with projects with IRRs in excess of 30%, each percentage point of IRR is expressed as a percentage point of enterprise value relative to project NPV, and
- That markets are more sceptical about projects with IRRs below 30% and value these companies at correspondingly lower percentages of NPV (as depicted by the arrows).

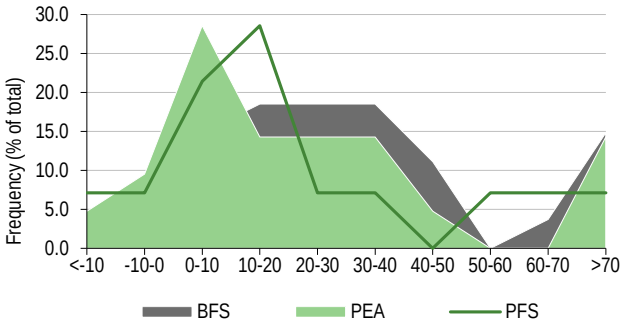
However, additional analysis suggests that such interpretations are, at best, simplistic. In the first instance, different types of studies appear to account for different valuations, with PEAs making up the single largest component of companies valued at 0-10% of NPV, PFSs making up the largest single component of companies valued at 10-20% of NPV and BFSs making up the largest single component of companies valued at 20-50% of NPV:

**Exhibit 131: Company EV as percent of attributable project NPV (%), by study type, density histogram**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

**Exhibit 132: Company EV as percent of attributable project NPV (%), by study type, probability density distribution**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Once again, readers' attention is drawn to the disproportionate sizes of the intervals to the extreme left (<-10%) and right (>70%) of the graphs. Also of note is the near-absence of company EVs in project EVs in the range 50-60% of respective NPVs. At this stage, it is probably a matter of opinion as to whether each curve in the right hand graph (Exhibit 132, above) is unimodal or bimodal (suggesting a market distinction between small and average sized projects and 'large' projects). Either way however, the curves appear to conform to a logical pattern for describing the probabilities of companies with particular study types performed on their project having a particular valuation. A summary of the data, in tabular form, is as follows:

**Exhibit 133: Company EV as percent of attributable project NPV (%), by study type, statistical summary**

| Study type | Minimum | Mode interval | Mean | Maximum | Range |
|---|---|---|---|---|---|
| PEA | -13.1% | 0-10% | 54.0% | 427.1% | 440.2% |
| PFS | -13.4% | 10-20% | 25.4% | 134.8% | 148.2% |
| BFS | 2.6% | 10-40% | 66.6% | 428.3% | 425.7% |
| All studies | -13.4% | 0-10% | 52.4% | 428.3% | 441.7% |

Source: Edison Investment Research, Thomson Reuters Datastream, company sources

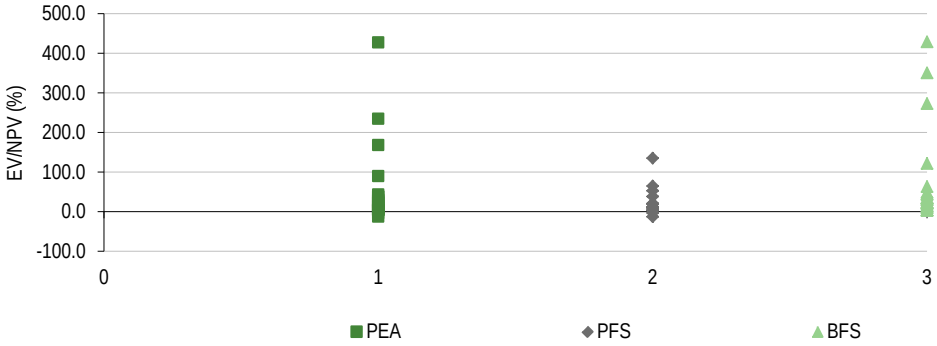
Assuming the curves in Exhibit 132 to be unimodal however, several features of these individual distributions are notable:

- The widest ranges of valuations occurs for companies with PEAs, followed by companies with BFSs, followed by companies with PFSs.
- With the exception of the curve describing PFS valuations, the mean of the curves describing companies with PEA and BFS level studies exist a long way to the right of their respective modes.

The skewness responsible for this second point, in particular, is significant, as it renders the use of the mean as a tool for predicting company valuations of questionable value. For example, to predict that a company with a PEA should attract a valuation of 54.0% of its project NPV would imply that it exists at precisely the point in Exhibit 132 at which there are no observable data points in Edison's sample. This may be considered to be strong evidence that the distribution of company valuations is bimodal, being composed of one population of exceptionally rated companies and another population of ordinarily rated companies.

The same data may also be depicted as follows:

**Exhibit 134: Company EV as percent of attributable project NPV (%), by study type**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

An alternative treatment, in order to reflect such a bimodal distribution, could be to distinguish between the two likely populations and exclude outlying valuations from the sample before deriving the mean for ordinarily valued companies in particular. This may be achieved via a number of methodologies. In this case however, Edison has chosen to exclude any data points that are more than one standard deviation from the mean, which then yields the following valuation range for ordinarily valued companies:

**Exhibit 135: Company EV as percent of attributable project NPV (%), by study type, ordinarily valued companies, excluding statistical outliers**

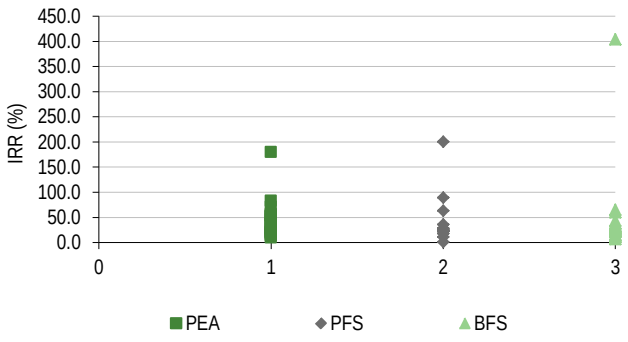
| Study type | Minimum valuation | Distribution mode | Mean valuation | Maximum valuation | Range |
|---|---|---|---|---|---|
| PEA | -13.1% | 0-10% | 18.9% | 90.0% | 103.1% |
| PFS | -3.7% | 10-20% | 16.3% | 52.6% | 56.3% |
| BFS | 2.6% | 10-40% | 29.6% | 121.5% | 118.9% |

Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Two features of the valuation range are notable in the aftermath of this treatment:

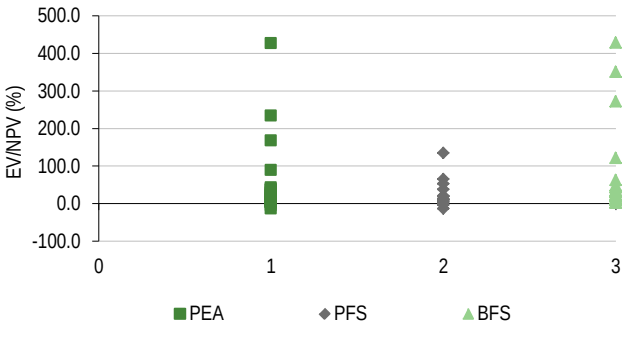
- The much closer alignment of the mean and the mode for ordinarily valued companies.
- The apparent 'anomaly', whereby the range is narrower and the mean lower for PFS compared to PEA level projects, persists. This may be explained by the generally higher IRRs associated with PEA stage projects compared to PFS ones, depicted graphically as follows in comparison to company valuations (in the form of the EV/NPV ratio):

**Exhibit 136: Average project IRRs, by study type (%)**




Source: Edison Investment Research, company sources

**Exhibit 137: Company EV as percent of attributable project NPV (%), by study type**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Note that the average IRR for companies with projects at PEA stage is 43.6%, while it is 40.7% for companies at PFS stage and 44.5% for companies at BFS stage – although note that, in each

case, there is a large degree of right skew in the distribution, as can be appreciated from a comparison of the position of the means with the actual distributions in Exhibit 128.

In the meantime, the valuation range for exceptionally valued companies is then as follows:

**Exhibit 138: Company EV as percent of attributable project NPV (%), by study type, exceptionally valued companies**

| Study type | Minimum valuation | Distribution mode | Mean valuation | Maximum valuation | Range |
|---|---|---|---|---|---|
| PEA | 167.5% | N/A | 276.3% | 427.1% | 259.6% |
| PFS | 64.8% | N/A | 99.8% | 134.8% | 70.0% |
| BFS | 272.3% | N/A | 350.3% | 428.3% | 156.0% |

Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Note the same anomaly for the valuation range and mean for PEA vs PFS level companies for exceptionally valued companies as for ordinarily valued ones.

## EV/NPV vs discount rates – comparing two Edison analyses

Edison first introduced differentiated market derived discount rates for companies at different stages of development in its report, Gold: New benchmarks for old, published in November 2012, and updated them in subsequent reports. Our most recently updated discount rates (to be applied to dividends rather than cash flows) are as follows:

**Exhibit 139: Market derived discount rates for companies at various stages of development (%)**

| | Scoping study/PEA | PFS | BFS | Development | Ramp-up | Production |
|---|---|---|---|---|---|---|
| Max discount rate (%) | 69.0 | 66.0 | 64.0 | 62.0 | 60.0 | 55.0 |
| Mean discount rate (%)* | 35.0 | 33.0 | 30.0 | 27.0 | 24.0 | 17.0 |
| Minimum discount rate (%) | 15.0 | 13.0 | 10.0 | 8.0 | 5.0 | 0.0 |

Source: Edison Investment Research. Note: To be applied to in conjunction with long-term metals' prices; *As interpreted by Edison Investment Research.

These discount rates from the basis of the valuation of NonSuch Gold on page 56. When expressed in terms of the ratio of the company's EV as a percentage of its NPV (at a 10% discount rate, applied to cash flows in the conventional manner), these discount rates yield the following percentages:

**Exhibit 140: NonSuch Gold EV as a percentage of project NPV, by stage of development**

| Percent | Scoping study/PEA | PFS | BFS |
|---|---|---|---|
| Maximum | 50.8 | 76.0 | 115.3 |
| Mid | 1.4 | 10.9 | 25.2 |
| Minimum | -9.1 | -4.6 | -1.0 |

Source: Edison Investment Research

These may be directly compared with those percentages derived from Edison's EV/NPV analysis in Exhibit 135, presented below transposed for easier comparison:

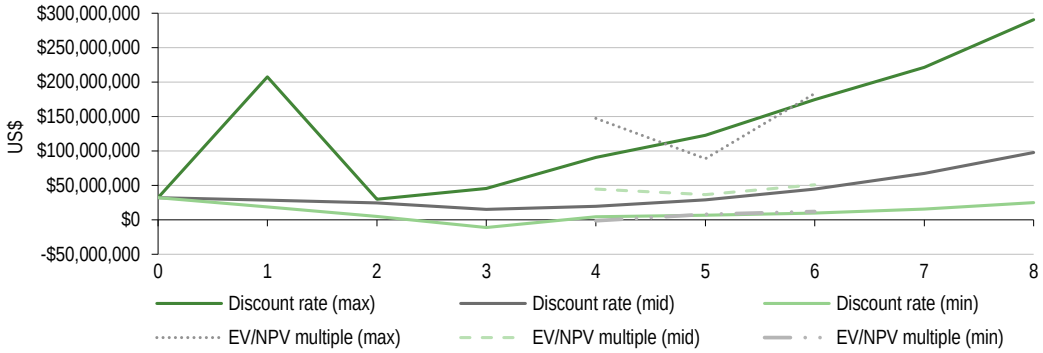
**Exhibit 141: Company EV as percent of attributable project NPV (%), by study type, ordinarily valued companies, excluding statistical outliers**

| Percent | Scoping study/PEA | PFS | BFS |
|---|---|---|---|
| Maximum | 90.0 | 52.6 | 121.5 |
| Mean | 18.9 | 16.3 | 29.6 |
| Minimum | -13.1 | -3.7 | 2.6 |

Source: Edison Investment Research

By contrast, if NonSuch Gold were to be valued according to the percentages derived from our EV/NPV analysis (Exhibit 141, above), then its valuation, depicted graphically, would compare to those derived using discount rates, as follows:

**Exhibit 142: NonSuch Gold valued with respect to 1) discount rates and 2) EV/NPV multiples, compared (US$)**




Source: Edison Investment Research. Note: 4 – Scoping study/preliminary economic assessment (PEA); 5 – Pre-feasibility study (PFS); 6 – Bankable feasibility study (BFS); 7 – Development; 8 – Production ramp-up.

Note that, in the above graph, year 4 corresponds to the year in which a scoping study (or preliminary economic assessment, PEA) is completed, year 5 corresponds to the year in which a pre-feasibility study is completed and year 6 corresponds to the year in which a bankable feasibility study is completed. Of note is the following:

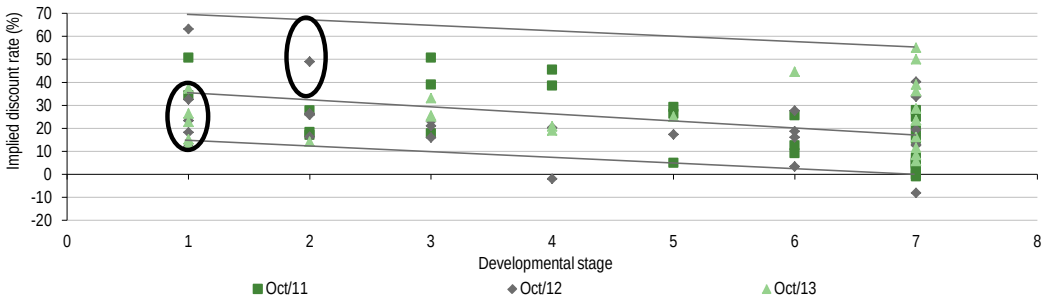
- The close correlation of the valuation results for companies at the bottom end of the valuation range by the two different methods of calculation.
- The close correlation of the valuation results for companies in the middle of the valuation range at BFS and PFS stage by the two different methods of calculation, but an anomaly at scoping study stage.
- The close correlation of the valuation results for companies at the top end of the valuation range at BFS stage by the two different methods of calculation, but anomalies at scoping study and PFS stage.

Note that the anomalies observed above correspond to those in Exhibit 135 on page 66 and discussed subsequently, whereby the range is narrower and the mean lower for PFS compared to PEA level projects. In terms of the discount rates used by Edison, it could imply:

- That Edison should give more weight to the greater concentration of companies with lower implied discount rates at scoping study level.
- That there may be more companies with higher discount rates at PFS level than recognised in Edison's discount rate sample (as depicted by the ovals below).

In summary, Edison is gratified by the relatively close correlation of the valuations of mining companies from scoping study to BFS stage via two entirely distinct valuation methods (EV/NPV and discount rate). Nevertheless, it recognises that, in comparison to its discount rate method, which implies a valuation trough at scoping study stage, the EV/NPV method suggests that there is a risk that that trough extends into PFS stage, potentially partly depending on how the IRR of the project develops through that evolutionary phase.

**Exhibit 143: Implied discount rates for companies at varying stages of development (October 2013, October 2012 and October 2011)**




Source: Edison Investment Research. Note: 1 – Scoping study/preliminary economic assessment (PEA); 2 – Pre-feasibility study (PFS); 3 – Bankable feasibility study (BFS); 4 – Development; 5 – Production ramp-up; 6 – Production from subsidiary asset (ie not the main asset); 7 – Full production from main asset.

## Conferring exceptionality – four parameters considered

In the following section, Edison analyses company valuations with respect to three variables in order to attempt to estimate the importance of each in determining the success of junior mining companies. The four variables are:

- Project internal rates of return (IRR).
- The Fraser Institute index of Investment Attractiveness for the country or jurisdiction in which a company's project (or projects) are located.
- Project size.
- Project grade.

### Internal rates of return (IRR)

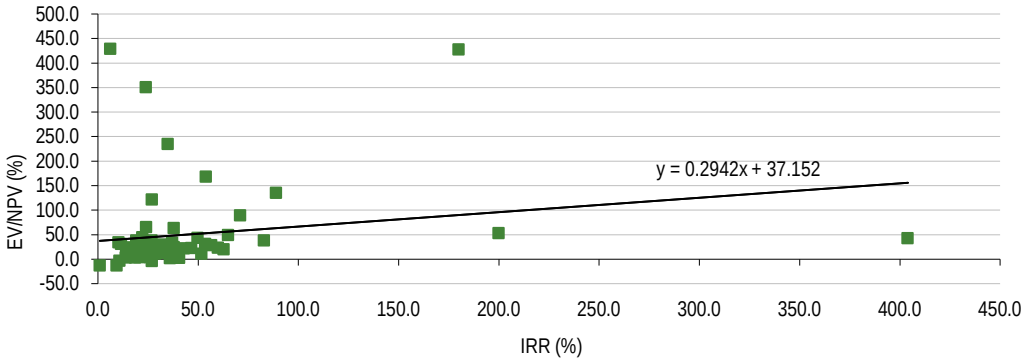
Key characteristics of almost any mining project include commodity and grade (on which depends overall ore payability), throughput (which governs revenue, costs and, to a large extent, capital intensity) and jurisdiction (on which depends a project's tax, royalty and rehabilitation regime). At the very least, all of these (and more) should be included in any analysis of a mining project's potential financial returns to investors in the form of the net present value (NPV) of future cash flows and also its internal rate of return (IRR). Whereas NPV depends on the (often rather arbitrary) choice of discount rate however, an IRR does not and is therefore a better measure of a project's overall capital efficiency and commerciality, compared to NPV which is often a better measure of size and scale. As such, it is possible to posit a relationship between a company's valuation with respect to its project NPV and its project IRR.

As we saw in the section entitled 'Relating company valuations to project economics', at first glance, it is tempting to make two conclusions:

- That, for companies with projects with IRRs in excess of 30%, each percentage point of IRR is expressed as a percentage point of enterprise value relative to project NPV, and
- That markets are more sceptical about projects with IRRs below 30% and value these companies at correspondingly lower percentages of NPV (as depicted by the arrows in Exhibit 130).

On further analysis however, it can be shown that the overall correlation between the two is weak (with a Pearson product-moment coefficient of just 0.186 – ie not statistically significant at the 5% level, given the number of data points analysed) and that the error of estimation is high at ±91.2% (ie predicting a company's EV/NPV ratio from an IRR has an error range in excess of most companies' relative valuations). This may be summarised as: it is not always the companies with the high IRRs that have the high valuations relative to NPV.

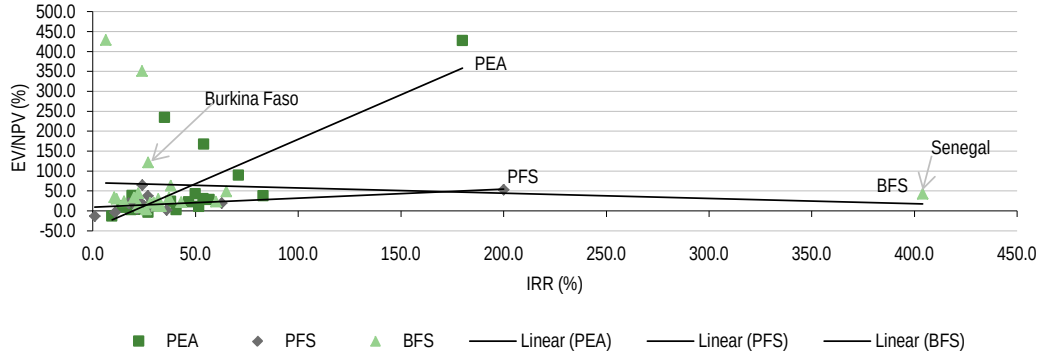
**Exhibit 144: Company EV as percent of attributable project NPV (%) vs project IRR (%)**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

If the analysis is differentiated by study type however, a markedly different pattern emerges:

**Exhibit 145: Company EV as percent of attributable project NPV (%) vs project IRR (%), by study type**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

In this case, the correlation between EV/NPV and IRR for companies with PEAs is a strong 0.79, while it is 0.51 for companies with PFSs – both of which are statistically significant at the 5% level, given the number of data points in the sample. Interestingly however, for companies with BFS level projects, there is effectively no correlation at all between EV/NPV and IRR, with a Pearson product-moment coefficient returned for this sample of -0.09.

In summary of this variable therefore, we may say that a company's valuation relative to its project NPV depends critically on that project's IRR at PEA stage of development, but that this relationship wanes to the point of irrelevance by the time that a BFS is completed on the project. Note however that the steepness of the best-fit line expressing the relationship between EV/NPV and IRR for a PEA stage project requires that the project has an IRR of at least 19.4%, on average, in order for any value at all to be conferred on the company.

Of equal note however is the fact that the top five companies by valuation (ie EV/NPV) are all located in NAFTA or Western Australia and it is not until the sixth company downwards that a project in a developing country (in this case, Burkina Faso) is represented. Similarly, of the three companies with the highest IRRs, the two with projects in Africa have EVs below 100% of NPV, whereas the third (which is in Mexico) has an EV well above 100% of NPV. This could imply that company valuations are closely related to the country or jurisdiction in which the project is located.

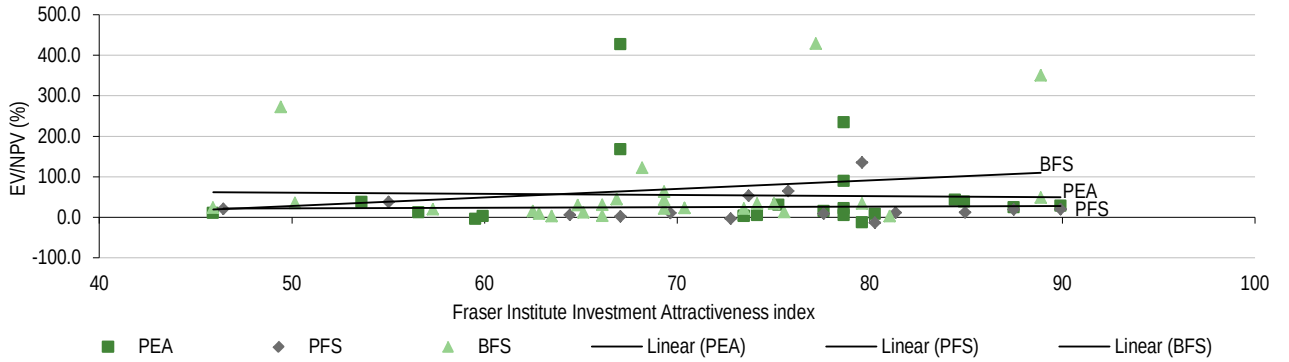
## The Fraser Institute Investment Attractiveness Index

There are so many facets of any one country's economy, legal framework and infrastructural characteristics (to name but a few) that it is difficult to find a single measure by which to rank them generally, let alone for mining specifically. Every year however, the Fraser Institute produces an Annual Survey of Mining Companies that numerically rates jurisdictions around the world based on a combination of their geological attractiveness for minerals and metals and their policy attractiveness. Headquartered in Vancouver, the Fraser Institute has regional offices in Calgary, Toronto and Montreal and, in 2017, was rated among the top 20 think tanks worldwide, in the Global Go-To Think Tanks Index published by the University of Pennsylvania.

Overall, the survey is an attempt to assess how mineral endowments and public policy factors such as taxation and regulatory uncertainty affect exploration investment. In addition to the Policy Perception Index and the Best Practices Mineral Potential Index however, the institute also creates a composite index that combines these two, known as the Investment Attractiveness Index, which recognises the fact that many investment decisions are often based not only on perceptions of government policy, but also on the pure mineral potential of a jurisdiction. In its most recent mining survey, for 2016, 104 jurisdictions were surveyed, returning Investment Attractiveness Index ratings from 24.83 (for Jujuy in Argentina) to 89.91 for Saskatchewan.

As such, it should be possible to posit a relationship between a company's valuation in the form of its EV/NPV ratio and its host country's (or state's) Fraser Institute Mining Investment Attractiveness score. In this case, the correlation is as follows:

**Exhibit 146: Company EV as percent of attributable project NPV (%) vs Fraser Institute Mining Investment Attractiveness index score, by study type**




Source: Fraser Institute, Edison Investment Research, Thomson Reuters Datastream, company sources

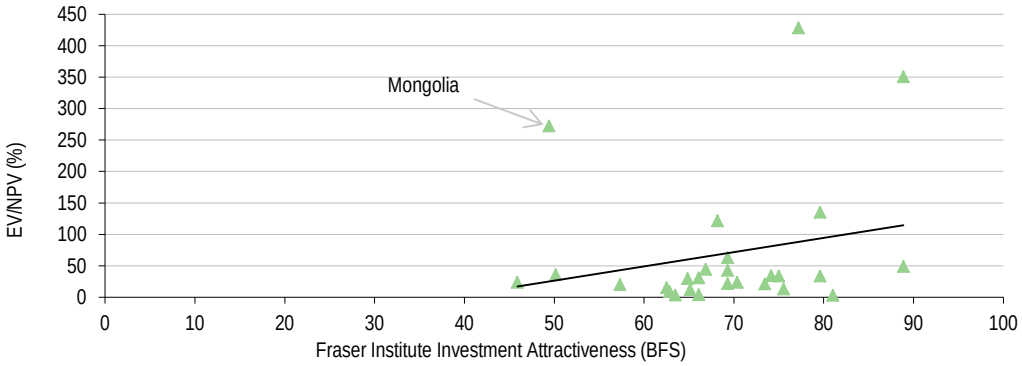
Notable features of the above analysis are as follows:

- Somewhat surprisingly, the overall correlation between a company's valuation (in the form of its EV/NPV ratio) and its project's host country's Fraser Institute Mining Investment Attractiveness Index score is low to the point of being almost random, with a Pearson product-moment coefficient of 0.05.
- Nevertheless, within the context of a low overall correlation, the Pearson product-moment coefficient is markedly higher for companies with projects at BFS level (0.20) compared to companies at PEA level (-0.03). The correlation for companies with projects at PFS level is 0.05. Note that none of these are statistically significant at the 5% level.
- The gradient of the line of best fit for companies with projects at PEA level is actually negative, which is counterintuitive.
- The gradient of the line of best fit for companies with projects at BFS level is such that it implies that a company in a country with a Fraser Institute Investment Attractiveness Index score of 36.9 will have an EV of zero (which encompasses the bottom seven ranked jurisdictions in the

survey; see Exhibit 117 on page 58). The gradients of the lines of best fit for companies with projects at both PEA and PFS level are such that the Investment Attractiveness Index score of all jurisdictions implies a positive EV (albeit with a large error of estimation, up to US$104.2m).

In conclusion, we can certainly say that the country's investment attractiveness (as expressed in its Fraser Institute survey score) is markedly less important than a project's IRR in determining the valuation of the company developing it. We can probably say, however, that the country in which the project is located becomes significantly more important as the project progresses from PEA stage to BFS stage. The graph below shows the relationship between valuation (in the form of EV/NPV) and a country's investment attractiveness for BFS stage projects only:

**Exhibit 147: Company EV as percent of attributable project NPV (%) vs Fraser Institute Mining Investment Attractiveness Index score for projects at BFS level only**




Source: Fraser Institute, Edison Investment Research, Thomson Reuters Datastream, company sources

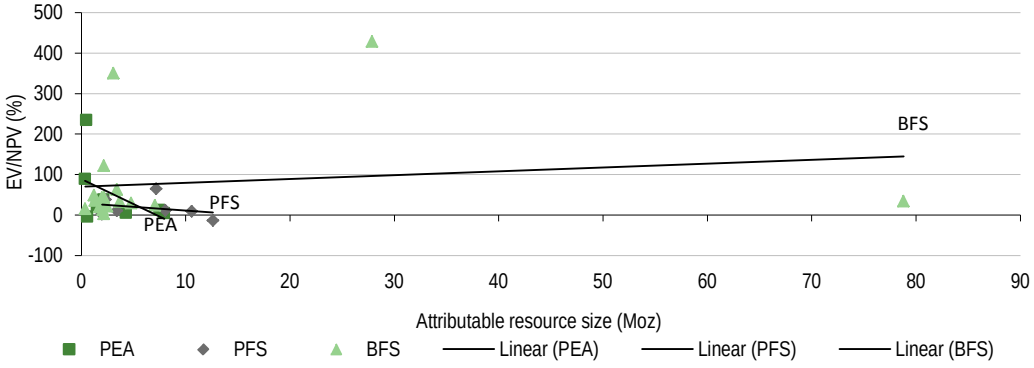
Note that if one outlier (namely the point relating to a project in Mongolia) is removed, then the Pearson product-moment coefficient of the above sample of data increases to 0.40, which is then statistically significant at the 5% level.

## Project size

For the two more technical variables (project size and grade), given the difficulty in converting from one mineral to another, the size of the sample of companies analysed was reduced to 32 gold companies.

For size, the correlation is as follows:

**Exhibit 148: Company EV as percent of attributable project NPV (%) vs attributable resource size, by study type**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Of note is the following:

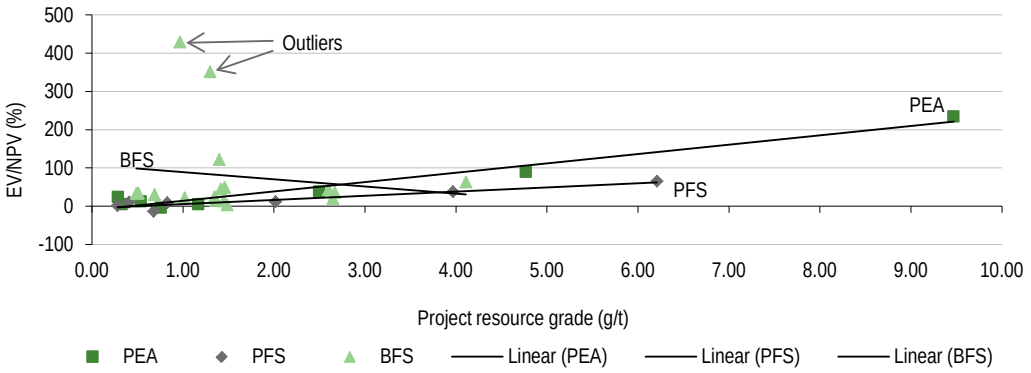
- The correlation between attributable resource size and EV/NPV is negative (but not statistically significant) for companies with projects at both PEA and PFS level.
- The correlation between attributable resource size and EV/NPV is positive (but not statistically significant) for companies with projects at BFS level.
- The overall correlation between attributable resource size and EV/NPV is positive (but not statistically significant).

While it is difficult to draw any strong conclusions from this sample of data, it is perhaps possible to say that, while resource size has no immediate effect on company valuations, it has a growing effect as projects evolve from PEA to BFS stage.

## Project grade

At first glance, the relationship between grade and company valuation is similarly weak:

**Exhibit 149: Company EV as percent of attributable project NPV (%) vs project resource grade, by study type**



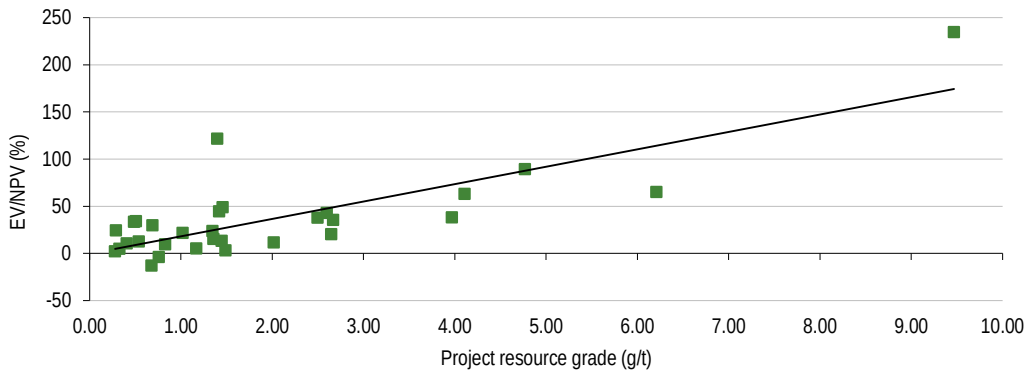

Source: Edison Investment Research, Thomson Reuters Datastream, company sources

In fact, the overall correlation between grade and company valuation is low, with a Pearson product-moment coefficient of 0.12. By study level however, a quite different pattern emerges:

- For companies with projects at PEA and PFS levels, there are extremely strong correlations between grade and company valuation. Pearson product-moment coefficients are 0.98 and 0.94, respectively.
- For companies with projects at BFS level, there is a correlation that is not statistically significant.

Moreover, if the two 'outliers' in Exhibit 149 are removed from the sample, then the correlation between grade and company valuation becomes very strong for all of the remaining data points (regardless of stage of development), with a Pearson product-moment coefficient of 0.80 (Exhibit 150, below):

**Exhibit 150: Company EV as percent of attributable project NPV (%) vs project resource grade, excluding outliers**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

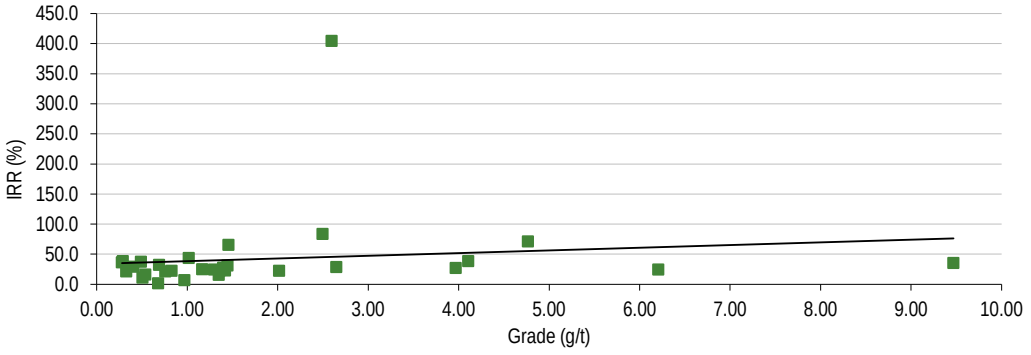
## Conclusions

In determining a company's valuation with respect to a number of variables therefore, we can probably safely conclude:

- IRRs are very important at early-stage, PEA level, projects, but become less so as the project is developed through to BFS. Nevertheless, statistically speaking, it is preferable to bring any project to the market with an IRR of at least 19.4% at PEA level.
- Jurisdiction is (apparently) not statistically significant at all until a project attains BFS level status and, even then, there will be exceptions.
- Project size becomes more important in determining a company's valuation, but could never be said to be significant at any stage.
- Project grade is very important, and particularly so for companies with early-stage PEA and PFS level projects. However, grade alone is not the determining factor in conferring 'exceptional' valuations on a company.

Interestingly, comparison between the correlations of IRR to valuation and grade to valuation perhaps indicate something that has been appreciated by investors in South Africa for some time – that there is little or no correlation (and certainly not a statistically significant one) between project grades and IRRs at almost any stage of a project's development:

**Exhibit 151: Project IRR (%) vs project resource grade (g/t)**




Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Qualitatively, Edison posits that there are six principal risks facing early-stage mining companies seeking to develop their projects. In no particular order, these are geography, geology, engineering, metallurgy, finance and management. Of these, the above analyses cover three of these risks,

namely geography, geology and financing (in the form of IRRs, which should be an indication of the financial attractiveness of a project). What is noticeable however is that, so far, there appears to be no 'silver bullet' in determining the project characteristics that confer on a company an exceptional valuation. If such a thing exists therefore, it may be among the remaining risks that Edison has identified – ie engineering, metallurgy or, in particular, management. In Edison's subjective opinion, we believe that it is likely to be the last of these (ie management) that is responsible for a disproportionate valuation relative to the tangible and financial characteristics of a project. If not, however, it may prove to be a complex combination of all of the above factors. As such, the apparent primacy of grade in the above correlations with company valuations may indicate a 'tick box' approach by the market in general, which may afford opportunities for discerning investors.

## Non-linearity and why it affects equity dilution

The following analysis was conceived by Edison as a thought experiment in order to study the effect of a company's discount to NPV on subsequent returns to equity holders. As such, it is a natural follow on from our price/NPV analysis in the preceding section (see pages 63-69).

To undertake the analysis, Edison conceived of a notional project that required a US$100m investment in order to generate cash flow of US$40m per annum. In scale therefore, the project was conceived to approximate a gold junior, such as NonSuch Gold (on page 56), although the two are not identical and should not be directly compared.

**Exhibit 152: Notional project cash flows (US$m)**

| US$m | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-financing cash flow | -100 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |

Source: Edison Investment Research

The project's notional cash flows are shown in Exhibit 152, above. Using a 10% discount rate, the net present value (NPV) of the above cash flows is US$132.5m and, assuming that the company has the same number of shares in issue, then the NPV per share is (conveniently) US$1.00. Note that the IRR of the project is 38.5%, which should be compared to the IRRs observed in the real world depicted in Exhibits 123 and 127 (ie slightly, but not excessively, high compared to the mode of the distribution, but below the mean). Initially, the company is presumed to have no cash and it will seek to finance the project on a 50:50 debt:equity basis, necessitating the raising of US$50m in the equity markets (note that the company's subsequent US$40m per annum cash flows are deemed to be stated after interest and debt capital repayments). If the company is able to raise equity at US$1.00 per share (ie at its NPV per share value), then it will issue an additional 50m shares, such that there will now be 182.5m shares in issue and the future return to equity holders, in the form of the net present value of future dividends discounted at 10% pa, will similarly be US$182.5m, or US$1.00 per share on a fully diluted basis – ie there will be no 'dilution' in the event that shares are sold at full 'value' in order finance the equity portion of the capex requirements of the project (as expected). 'Full' financials are provided in the table below:

**Exhibit 153: Notional project financials (US$m)**

| | Year 0 | Year 1 | Year 2 | Year 3 | Year 4 | Year 5 | Year 6 | Year 7 | Year 8 | Year 9 | Year 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cash from operations | 0 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Capex | -100 | | | | | | | | | | |
| Pre-financing cash-flow | -100 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Equity financing | 50 | | | | | | | | | | |
| Cash-flow | -50 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Cash at start of period | 0 | -50 | -10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cash/(debt) at end of period before dividend | -50 | -10 | 30 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Dividend | 0 | 0 | 30 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| Cash/(debt) at end of period | -50 | -10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DCF (US$m) | 132.5 | | | | | | | | | | |
| Ditto per initial share (US$/share) | 1.00 | | | | | | | | | | |
| DDF* (US$m) | 182.9 | 201.2 | 221.3 | 213.4 | 194.7 | 174.2 | 151.6 | 126.8 | 99.5 | 69.4 | 36.4 |
| Ditto per final share (US$/share) | 1.00 | 1.10 | 1.21 | 1.17 | 1.07 | 0.95 | 0.83 | 0.69 | 0.54 | 0.38 | 0.20 |
| No. of shares at start (millions) | 132.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 |
| New shares re financing (millions) | 50.0 | | | | | | | | | | |
| No. of shares at end of period (millions) | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 | 182.5 |
| DCF per share (US$/share) | 1.00 | | | | | | | | | | |
| Share price discount to value (%) | 0 | | | | | | | | | | |
| Share price (US$/share) | 1.00 | | | | | | | | | | |
| DPS per share (US$) | 0 | 0.00 | 0.16 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 | 0.22 |
| DDF* per share (US$) | 1.00 | 1.10 | 1.21 | 1.17 | 1.07 | 0.95 | 0.83 | 0.69 | 0.54 | 0.38 | 0.20 |

Source: Edison Investment Research. Note: *DDF = Discounted dividend flow assuming company distributes all excess cash to shareholders.

Now consider the instance in which shares are instead sold at a 50% discount to the NPV value of the project in order to fund the equity portion of capex – ie at US$0.50/share. In this case, the discounted cash flow of the project remains US$132.5m and the discounted dividend flow (DDF) US$182.9m. However, now that same DDF value will be divided into 232.5m shares (132.5m original shares plus 100.0m new shares), such that the overall DDF per share reduces to US$0.79/share. In capital terms, this represents a 57.3% positive capital return for 'new' shareholders (who acquired their shares at US$0.50 each) and a 21.4% negative capital return for 'old' shareholders (who acquired their shares at US$1.00 each). In income terms, an investor in the new shares, at US$0.50/share, would experience an IRR of 18.2% per annum, while an investor in the old shares, at US$1.00/share, would experience an IRR of 6.1% per annum. Relative to the 10% per annum IRR that both would experience if new shares were sold at zero discount (ie at US$1.00/share), new shareholders experience an 8.2 percentage point uplift, while old shareholders experience a 3.9 percentage point reduction. Over the full range, the potential effect on capital and income returns for both 'old' and 'new' shareholders from selling shares at various discounts to NPV is as follows:

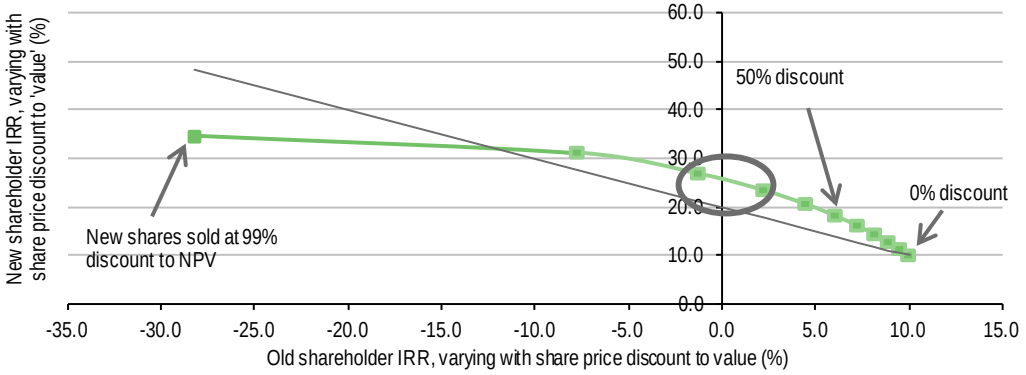
**Exhibit 154: Capital and income returns for project investors, pre- and post-financing**

| Share price discount to NPV (%) | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 99 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Financing share price (US$/share) | 1.00 | 0.90 | 0.80 | 0.70 | 0.60 | 0.50 | 0.40 | 0.30 | 0.20 | 0.10 | 0.01 |
| DDF* (US$/share) | 1.00 | 0.97 | 0.94 | 0.90 | 0.85 | 0.79 | 0.71 | 0.61 | 0.48 | 0.29 | 0.04 |
| Capital uplift for new shareholders (%) | 0.0 | 8.0 | 17.2 | 28.1 | 41.2 | 57.3 | 77.5 | 103.7 | 139.0 | 189.1 | 256.3 |
| Capital reduction for existing shareholders (%) | 0.0 | (2.8) | (6.2) | (10.3) | (15.3) | (21.4) | (29.0) | (38.9) | (52.2) | (71.1) | (96.4) |
| Old shareholder IRR (%) | 10.0 | 9.5 | 8.9 | 8.2 | 7.3 | 6.1 | 4.5 | 2.3 | (1.2) | (7.7) | (28.2) |
| New shareholder IRR (%) | 10.0 | 11.3 | 12.7 | 14.3 | 16.1 | 18.2 | 20.6 | 23.4 | 26.8 | 31.1 | 34.6 |

Source: Edison Investment Research. Note: *DDF = Discounted dividend flow.

In graphical terms, the variation of 'old' shareholder IRR and 'new' shareholder IRR with the discount at which shares are sold relative to NPV in order to finance the project is as follows:

**Exhibit 155: Graph of 'new' shareholder IRR (%) vs 'old' shareholder IRR %), varying with discount to NPV**




Source: Edison Investment Research. Note: See text below for explanation of grey line of equivalence.

As can be seen from the above graph, ever increasing discounts at which shares are sold relative to NPV in order to finance a project result in ever increasing returns for 'new' shareholders and ever decreasing returns for 'old' shareholders. However, what is gained by the one is not offset by what is lost by the other – that is to say, the relationship between the two is asymmetric and non-linear.

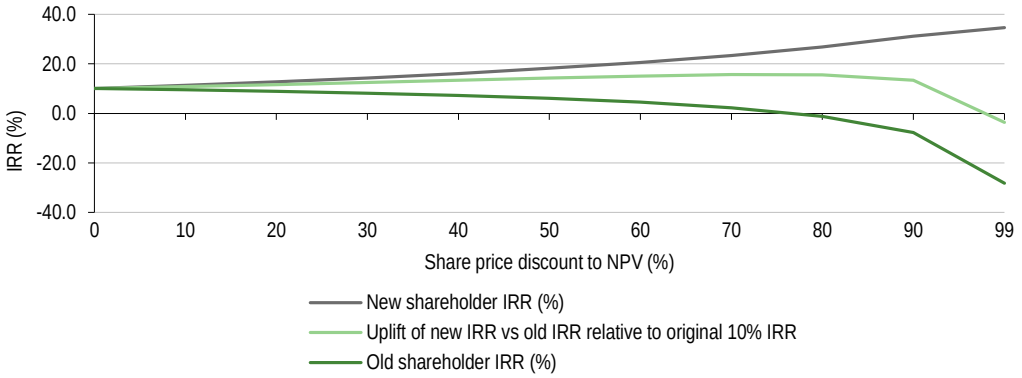
It is taken as read that readers appreciate that the returns of 'old' shareholders can be protected in the event that they subscribe for 'new' shares pro-rata to their interest in 'old' shares. In that case, the 'excess' returns from investing in a proportionate number of 'new' shares exactly compensate for the reductions in returns from 'old' shares, regardless of the price at which the financing is conducted (along the lines of a rights issue). However, this does not apply in the event that 'new'

shareholders are not the same as 'old' shareholders, in which case the excess returns accruing to the former are, in effect, financed by the latter.

The grey line in the above graph represents a line of equivalence, marking the point at which each percentage point of return foregone by 'old' investors is compensated by an additional percentage point of return earned by 'new' investors. Immediately obvious from this is the fact that, owing to the non-linearity of the returns curve, ever increasing discounts to NPV (to beyond 90%) initially result in greater returns for 'new' investors than are foregone by 'old' investors, with the point of maximum excess returns to 'new' investors occurring at an approximately 70-80% discount to NPV (as depicted by the oval). At this point, the overall income return (or IRR) to 'old' shareholders in the project is c 0.5% (ie 9.5% less than would be achieved if new shares were issued at a 0% discount to NPV), while the income return to new shareholders is close to 25% (ie 15% higher than would be achieved if new shares were issued at a 0% discount to NPV).

As such, it should be no surprise that 'new' investors in a mining project (in the form of 'the market') expect to negotiate to pay 20-30% of project NPV, being cognisant of the fact that excess income returns to them at this level outweigh those returns foregone by 'old' shareholders. Stated alternatively, old shareholders at an entry price of US$1.00/share would continue to experience a positive percentage return by subscribing for one 'new' share for each share that they already hold at a 70-80% discount to NPV. The same data may be displayed as follows:

**Exhibit 156: Graph of 'new' shareholder IRR (%) vs 'old' shareholder IRR %), varying with share price discount to NPV (%)**




Source: Edison Investment Research

# Gold price

Edison's long-term gold price forecasts draw on gold's historical relationships to both inflation and the US monetary base, which we believe is apt, given the US Federal Reserve's plans to shrink its balance sheet by a third over the course of the next five years. Nevertheless, in 2017, owing to the unprecedented breakdown in the historical relationship between the total US monetary base and inflation, we have also introduced an analysis that forecasts the price of gold based on its historically statistically significant relationship with US currency in circulation.

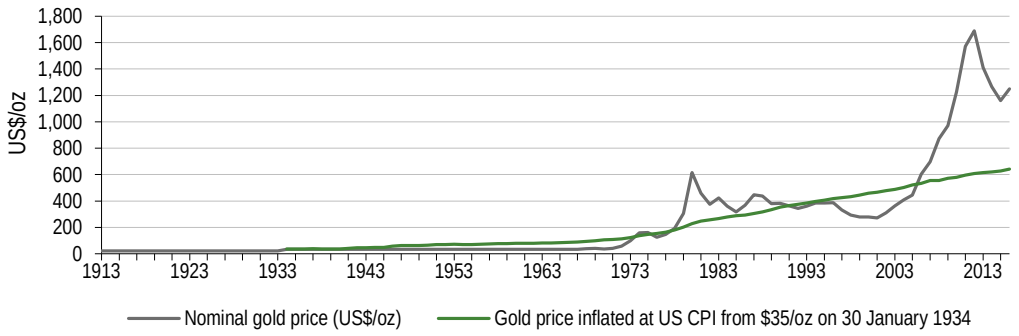
## The gold price's relationship with US dollar inflation

Since 1945, gold can be seen to have undergone at least two completed bull and two completed bear markets:

- A bear market between 1945 and 1967 (a period that was characterised by inflation and positive real interest rates).
- A bull market between 1968 and 1980 (a period of negative real interest rates).
- A bear market from 1980 to 2001 (positive real interest rates).
- A bull market again from 2001 to 2012 (again characterised by negative real interest rates).

The bear market from 2012 has been generally characterised once again by the expectation of a resumption of positive real interest rates. Note however that the average price of gold in 2016 (US$1,250/oz) was 7.8% higher than in 2015 (US$1,160/oz) and the year-to-date average in 2017 has been US$1,255/oz. However, this alone would not yet cause us to fundamentally reconsider our interpretation above.

**Exhibit 157: Nominal gold price (1913-2015) and indexed from US$35/oz in January 1934 (US$/oz)**




Source: Edison Investment Research, South African Chamber of Mines, US Department of Labor. Note: Prices are annual averages.

Between 1945 and 1971, the gold price was formally linked to the US dollar. Towards the end of this period, however, the US began both to run twin deficits and to expand the money supply. As a result, international creditors (particularly France) began to sterilise dollar foreign exchange reserves into gold, which put upward pressure on the price of gold and downward pressure on the dollar. After a series of initiatives aimed at preserving the Bretton Woods order, President Nixon finally abandoned the link in August 1971. The subsequent devaluation of the dollar had the effect, among other things, of importing inflation into the United States, which jumped from a containable 3.4% in 1972 to a virtually unprecedented 8.7% in 1973. The Federal Reserve reacted conventionally by tightening monetary policy, which comprehensively burst the internal US credit bubble and started to suck markets into a debilitating debt-deflation spiral. As a result, the Dow Jones Industrials average lost 45% of its value in 1973-74, while the US economy slowed from

7.2% real GDP growth in 1972 to a 2.1% contraction in 1974. Now facing the prospect of a depression, the Fed reacted equally conventionally by reducing interest rates to the minimum possible and by expanding the US monetary base. Inevitably, this put further downward pressure on the value of the dollar and imported price rises, leading to a second peak in inflation later in 1979, which was only brought under control after Paul Volcker's decision to raise interest rates to defend the value of the dollar in international foreign exchange markets at the expense of a further debilitating recession in the early 1980s. Positive interest rates having once again been re-imposed, international markets returned to something approaching normality, albeit with the dollar (and sterling) at permanently lower levels compared to the currencies of international creditor nations such as Germany, France and Japan.

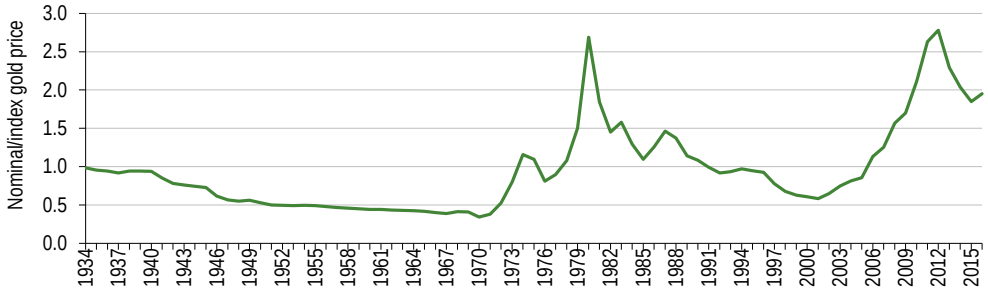
As positive real interest rates reasserted themselves in 1980, so currency markets stabilised and gold returned to a bear market phase that lasted until 2001 (analogous to the period of 1945-68). Hence, whereas the German mark appreciated by 66% against the US dollar during the 1970s, in 1999 the DEM/US$ rate was recognisably similar to that in 1980.

As the new millennium dawned, however, (and after a period of relative economic stability) the US once again began to run twin deficits as a result of a combination of the "war on terror" and the rise of a new economic competitor and international creditor in the form of China, which resulted in:

1. The return of negative real interest rates in 2001.
2. Inflation and a subsequent rise in interest rates in 2007.
3. The bursting of the credit bubble, subsequent banking failures (Bear Stearns, Lehman Brothers, etc) and the beginnings of a debt-deflation spiral in 2007-09.
4. The adoption of unconventional monetary policy in the form of three rounds of quantitative easing (QE1, QE2 and QE3) from 2008 until 2014.

The two completed bull and bear markets may easily be seen by comparing the actual price of gold to the price when indexed from US$35/oz in January 1934 using the US consumer price index (CPI):

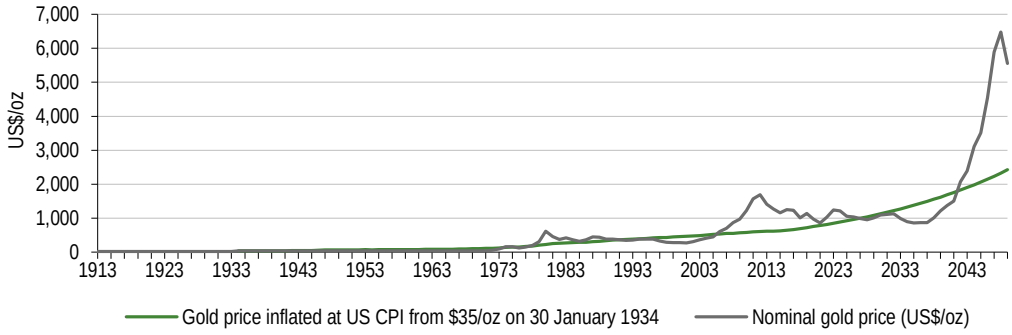
**Exhibit 158: Nominal gold price divided by index gold price, 1934-2015**




Source: Edison Investment Research, South African Chamber of Mines, US Department of Labor

Taken at face value, it is easy to conclude that gold's peak price in 2012 was equivalent to that in 1980 and that it has just started another 21-year bear market. In this case, the degree of divergence in 2016 can be seen to be similar to that in 1981. Using this as a benchmark and projecting the indexed level of gold into the future at the same average historical rate of US CPI inflation between 1972 and 2016 and then applying the same cyclical discount or premium depicted above generates the following future gold price profile:

**Exhibit 159: Gold price, historical and forecast with respect to 1934 price (indexed), 1913-2049**



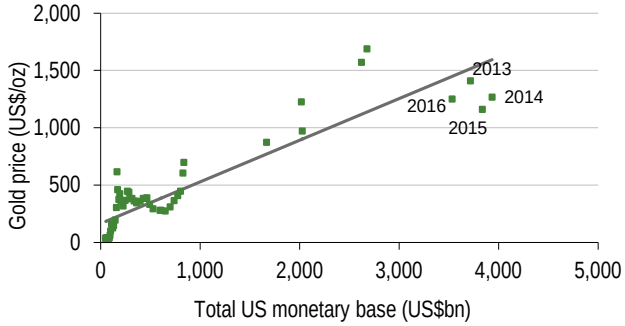

Source: Edison Investment Research and (historical) South African Chamber of Mines, US Department of Labor. Note: Prices are annual averages

On this basis, gold may be expected trade between US$860/oz and US$1,250/oz for the next 20 years before starting another bull run in 2040, which will take it to c US$6,500/oz by 2049.

## Gold price relationship with US total monetary base

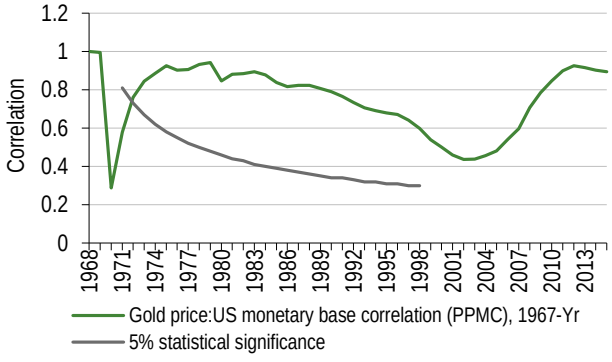
In addition to its relationship with inflation however, gold also exhibits a very close, statistically significant relationship with the US total monetary base. At the present time, the relationship between the two elicits a Pearson product-moment coefficient (PPMC) of 0.902 (vs 0.896 at the time of Edison's last note, Mining overview: Normalisation augers well for exploration, published in October 2016), implying that there is less than a 5% chance that the relationship occurred by chance. This may be rationalised as the value of US gold holdings having a very close correlation with the total US monetary base (with a PPMC of 0.903 since 1967), which reduces to the gold price having a very close correlation with the total US monetary base, given that the gold tonnage held by the Federal Reserve as a reserve asset has remained effectively unchanged since 1979 (and, arguably, earlier).

**Exhibit 160: Gold price vs US total monetary base, regression analysis, 1959-2016**




Source: Edison Investment Research, Federal Reserve, dollardaze.org

**Exhibit 161: Gold price and US total monetary base correlation, 1968-2016**



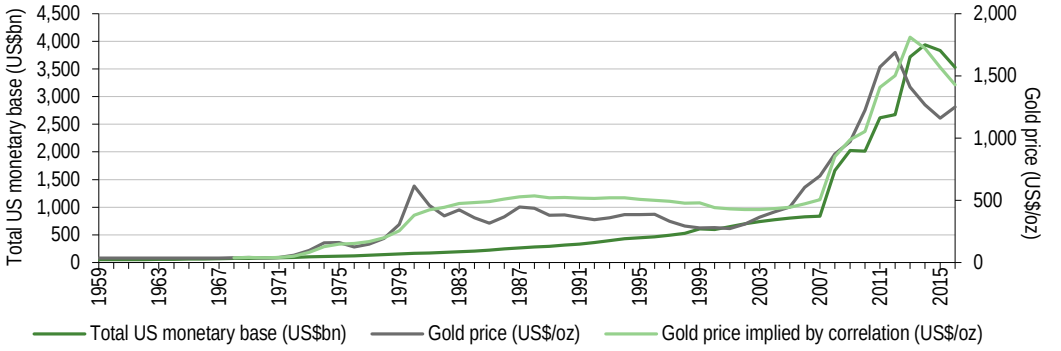

Source: Edison Investment Research and (underlying data) Federal Reserve, dollardaze.org

Since 2007, the US Federal Reserve has increased the US total monetary base by 4.2 times, or US$2.7tn, to US$3.5tn to the end of 2016 – although there have actually, already, been declines in 2015 and 2016. This compares to losses in the US economy at the height of the economic crisis of around US$9.0tn. However, US$4.8tn of the US$9.0tn related to retirement assets, savings and pension assets, which are closely related to the stock market. Given that the Dow Jones is now

(November 2017) at a level that is comfortably above its pre-crisis level of c 14,000 in September 2007, it is not unreasonable to surmise that these losses have been recouped. At the same time, US house prices appear to have recouped approximately half of their losses at the time of the crisis, such that the Federal Reserve has, as of now, in fact 'printed' US$2.7tn in new money in order to cover a nationwide loss of c US$2.1tn in home equity – ie it has covered c 129% of the loss.

Exhibit 162 depicts the gold price and the US total monetary base since 1959, as well as a forecast estimate of the level of the gold price had it been predicted solely on the basis of its relationship with the US total monetary base as it would have been perceived at the time:

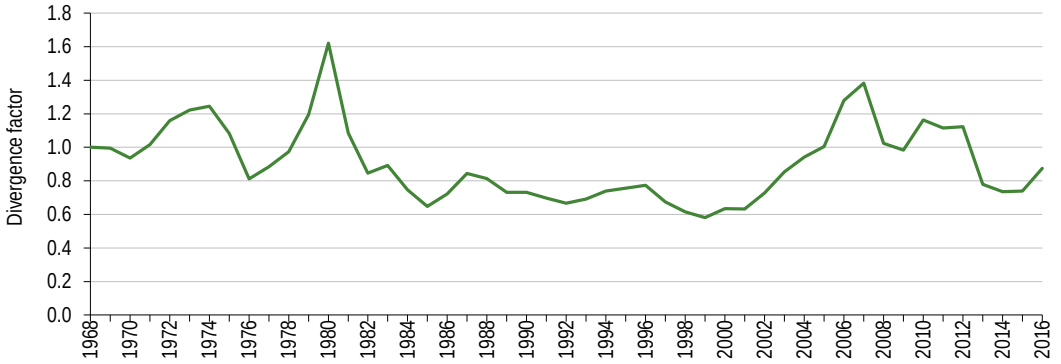
**Exhibit 162: Gold price, US total monetary base and predicted gold price, 1959-2016**




Source: Edison Investment Research and (underlying historical data) Federal Reserve, dollardaze.org

In 2016, the discount of the actual price of gold compared to the predicted one was 12.7%, which represented a decline compared to the 27.3% discount recorded in 2015. Note that, statistically, the error of estimation of the regression analysis is ±US$183/oz. Exhibit 163 graphs the variation of the actual gold price from the predicted one since 1968.

**Exhibit 163: Variation of actual gold price from predicted, 1968-2016**




Source: Edison Investment Research and (underlying data) Federal Reserve, South African Chamber of Mines, dollardaze.org

On this basis, the gold price can be said to have reverted rapidly from the premiums that were typical of bull market conditions in 2005-12 to those that are typical of bear market conditions in 2013-16. Arguably, 2016 may be regarded as being akin to 1987, in that both marked the culmination of a two-year period of a strengthening gold price and a narrowing discount compared to that predicted by the level of the total US monetary base.

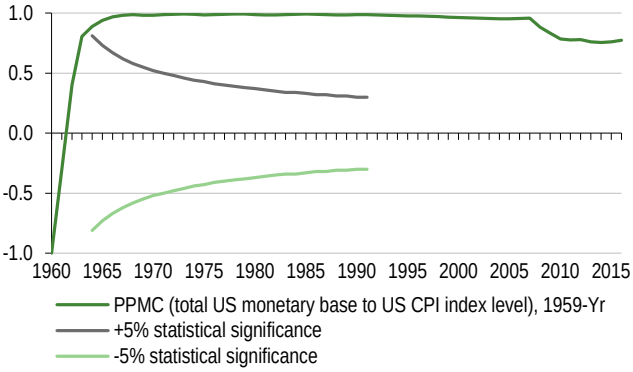
On the basis of the historical correlation between the two:

- The current gold price (US$1,279/oz at the time of writing) discounts a total US monetary base of US$3.1tn (cf US$3.5tn at end-2016 and US$3.8tn at the time of writing).
- The end-2016 total US monetary base of US$3.5tn implies a gold price of US$1,448/oz.
- The forecast end-2017 total monetary base of US$3.8tn implies a gold price of US$1,555/oz.

## Reflecting a monetary paradox

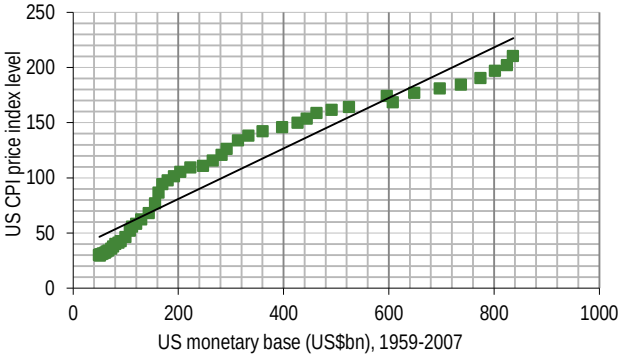
The gold price can be seen to be expensive with respect to indexed prices (or, stated alternatively, it has more than acquitted itself as a store of value and a hedge against inflation), but cheap relative to the monetary base. At first glance this appears to be a paradox, especially since the historical relationship between prices in general and the total US monetary base has been extremely close (eg a Pearson product-moment coefficient of 0.957 between 1959 and 2007):

**Exhibit 164: Correlation (PPMC), total monetary base to US CPI level, 1959-2016**




Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

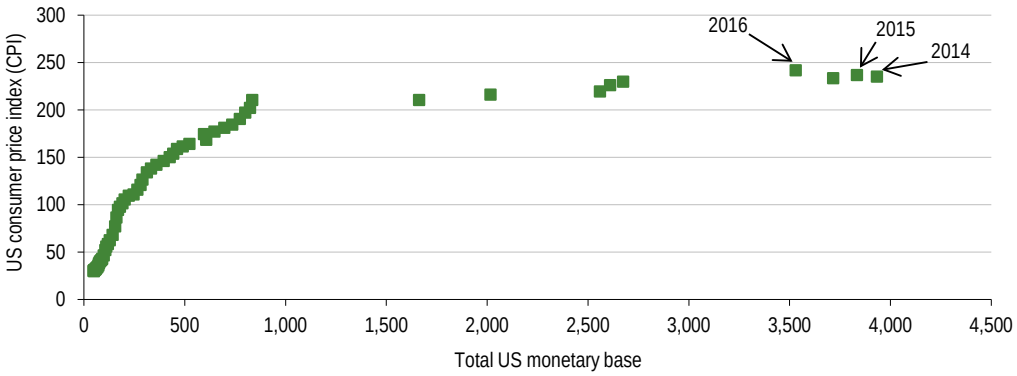
**Exhibit 165: Scattergram, total monetary base vs price levels, 1959-2007**




Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

Since 2007 however, the relationship appears to have almost completely broken down, with the US total monetary base recording annual increases of 99%, 21%, 27%, 2%, 2%, 39% 6%, -3% and -8%, while (over the same timeframe) prices have increased by only 14.9% (or 1.6% per annum, on average):

**Exhibit 166: Scattergram, total monetary base vs US CPI level, 1959-2016**

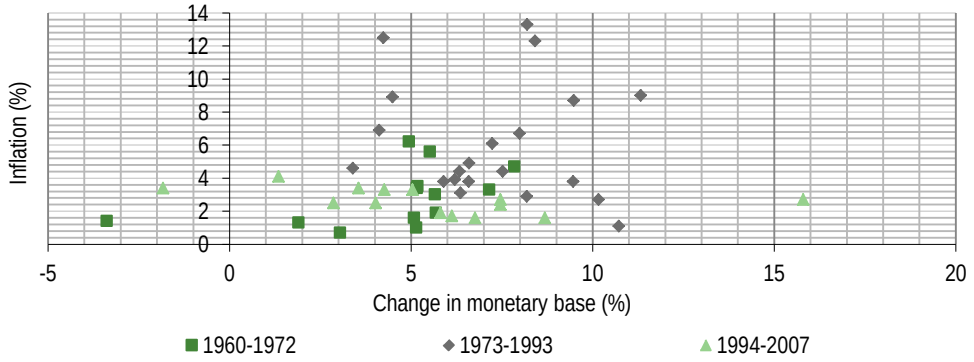



Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

This is all the more striking when the historical relationship between inflation and changes in the monetary base is considered. Traditionally, increases in the total monetary base have been 6.0% per annum (geometric mean). Currently, the relationship between the two cannot be said to be statistically significant. However, it certainly was between 1973 and 1992. Moreover, as Exhibit 167

demonstrates, there appears to be an increased risk of inflation in the event that the total monetary base increases by more than 4% per annum:

**Exhibit 167: Scattergram, US CPI inflation vs change in total US monetary base, 1960-2007**




Source: Edison Investment Research, US Department of Labor, Federal Reserve, dollardaze.org

In fact, were the two to maintain the relationship that they had prior to the first tranche of quantitative easing, given the current total US monetary base, the CPI index should be 843.0, or 3.5x its current level.

Given the historical relationship between the two, the obvious conclusion is that price rises in the general economy have not kept pace with increases in the total monetary base. The gold price has risen by more than general prices in the past 15 years – arguably in part on account of increases in the total monetary base – but not by as much as the increase in narrow money. As a result, it is at a premium to its indexed level, but at a discount to the level implied by its correlation with the total US monetary base.

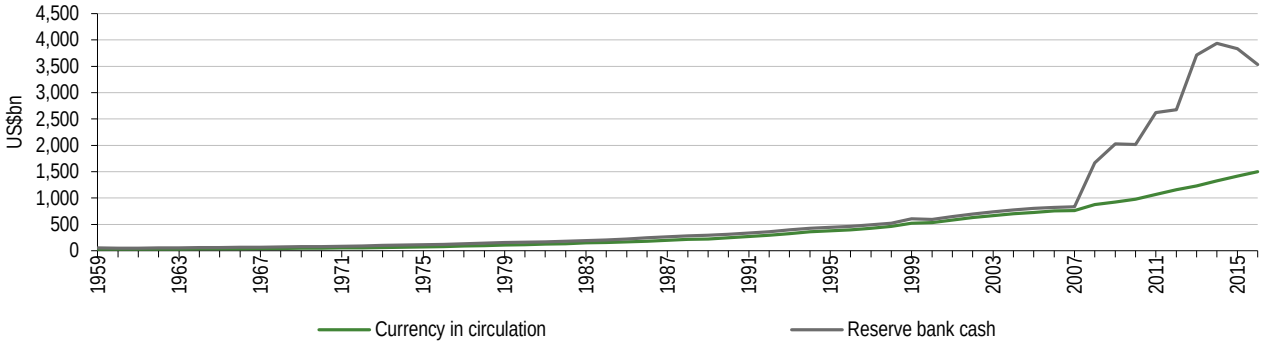
## Currency in circulation vs total monetary base

Probably the simplest explanation for the apparent breakdown in the relationship between the US total monetary base and prices/inflation relates to the amount of currency in circulation in the US economy.

The total US monetary base is made up of two components: 1) currency in circulation and 2) total reserve balances maintained by banks and depositary institutions at the Federal Reserve (crudely, currency that could be in circulation).

Traditionally, currency in circulation has made up the majority of the total monetary base. In fact, between 1959 and 2007, it accounted for an average 74% of the total monetary base, with a maximum of 91% (in 2006) and a minimum of 57% (in 1959). During the period since the start of quantitative easing however, this proportion has reduced sharply. Arguably, the increase in the total monetary base is what was required in order to maintain growth in currency in circulation:

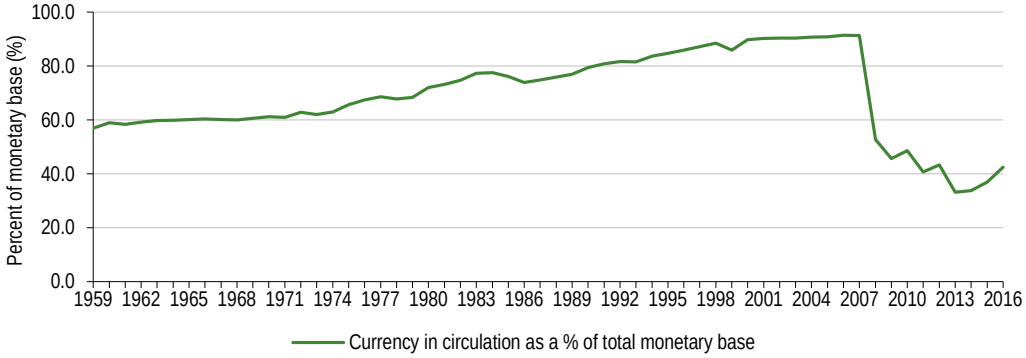
**Exhibit 168: US currency in circulation vs total monetary base, 1959-2016**




Source: Edison Investment Research, Federal Reserve, dollardaze.org

Nevertheless, it leaves the proportion of currency in circulation as a percentage of the US total monetary base at just 42.5% as at end-2016 – above 2013's post-1959 low of 33.1%, but still little more than half the pre-2007 average.

**Exhibit 169: Currency in circulation as a percentage of the US total monetary base, 1959-2016**




Source: Edison Investment Research, Federal Reserve, dollardaze.org

The correlation between the gold price and currency in circulation (0.887 for the period 1959-2016) is not quite as strong as between the gold price and the total monetary base (0.900 for 1967-2016). Nevertheless, it is significant and, at the current time, US currency in circulation of US$1.5tn implies a gold price of US$1,427/oz (note that currency in circulation increased in both 2015 and 2016 in contrast to the total monetary base, which declined).

## The big shrink

### Background

When Janet Yellen announced the end of its bond buying programme in October 2014, the Federal Reserve's balance sheet had reached US$4.5tn (including US$2.5tn of Treasuries and US$1.8tn in mortgage backed securities, or MBS) and the total US monetary base US$3.9tn. By reinvesting principal payments and maturing securities, both have remained at or about that level ever since.

### Politics

In contrast to our equivalent analysis in October 2016, until the election of Donald Trump as US president, the possibility of the Fed actively selling securities in order to reduce its balance sheet was regarded as unlikely owing to the effect that such a policy would have on market interest rates

and, potentially, volatility. However, Mr Trump has been highly critical of the Federal Reserve, while many Republican economists have actively criticised quantitative easing.

At the moment, the Federal Reserve is believed to favour a relatively large balance sheet and therefore a relatively big presence in money markets. In deference to its political masters and the big banks however, it has drawn up plans to shrink its balance sheet in order to minimise its influence in the private sector.

## Economics

In order to soften the impact of a shrinking balance sheet, at the Federal Reserve meeting in June, committee members agreed that, rather than outright asset sales, they would start by letting US$6bn a month in maturing Treasuries run off, which will then increase to US$30bn pm, while mortgage backed securities will run off at a rate of US$4bn pm, rising to US$20bn. Note that this total of US$50bn per month compares with the ultimate level of bond buying during QE3 of US$85bn per month. Moreover, while the rate of amortisation of mortgage backed securities is estimated to be c 1% per month (such that the US$20bn maximum cap for MBS should allow for essentially unrestricted roll off), Treasury amortisation is uneven from month to month with the result that the US$30bn maximum monthly cap is likely to force the Fed to continue to purchase Treasury bonds in some months. Nevertheless, under the FOMC's plan for Treasury roll off, the Federal Reserve's holdings of Treasury securities should decline at a rate of c 11% per annum. Any reduction in demand as a result of its shrinking balance sheet will be mitigated by lowering the anticipated path of interest rate increases (see Gold considered as a currency on page 89).

While there was some debate about the precise timing of tapering, on 20 September, the Fed finally set the wheels in motion by announcing that the process would begin in October. In the long term, the Fed said that it plans to keep its balance sheet "appreciably below that seen in recent years but larger than before the financial crisis." Once it falls below US$3.0tn however, there will be a further discussion as to how big the Fed's balance sheet should be once tapering is over. As such, the earliest that the Federal Reserve could reasonably start to expand its balance sheet once again is mid-2020. Over the course of the entire balance sheet reduction programme however, Edison's forecasts for combined Treasury bond and MBS run off per annum are as follows:

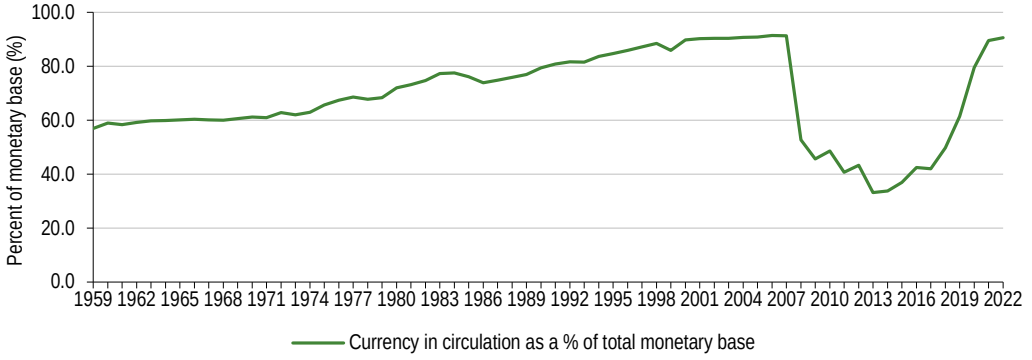
**Exhibit 170: Projected reduction of Federal Reserve's assets, by year**

| Year | Reduction (US$bn) | Percentage of total (%) |
|---|---|---|
| 2017 | 20 | 1.4 |
| 2018 | 360 | 24.3 |
| 2019 | 463 | 31.3 |
| 2020 | 515 | 34.8 |
| 2021 | 122 | 8.2 |
| Total | 1,480 | 100.0 |

Source: Edison Investment Research

Note that on the assumption that reductions in Federal Reserve assets are similarly reflected in the total US monetary base, while currency in circulation continues its 'upward-only' trajectory, we estimate that the latter will revert to near the top end of its historic range as a percentage of the former by 2022:

**Exhibit 171: Currency in circulation as a percentage of the US total monetary base, 1959-2022e**

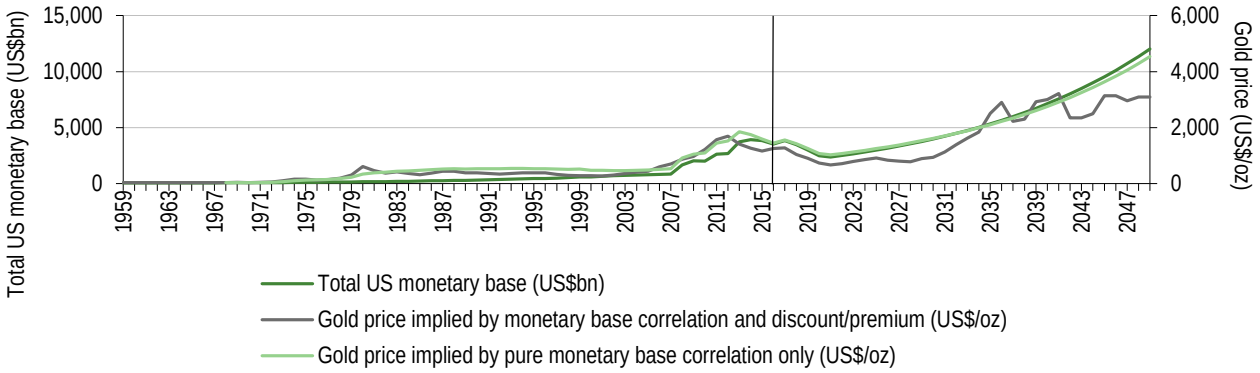



Source: Edison Investment Research, Federal Reserve, dollardaze.org

## The potential effect on the gold price

Since November 2013, one aspect of Edison's gold price forecasts has been its historically statistically significant correlation with the total US monetary base. As stated previously, for the purposes of our forecasts, future reductions in the Federal Reserve's assets are assumed to be reflected also in reductions in the total US monetary base. From its most recent level of US$3.8tn therefore, we forecast that the total US monetary base will decline to US$2.4tn in 2021 (below the level that it was at before QE3 was announced in September 2012), before resuming an upward trajectory again at its long-term growth rate of 6.0% per annum. If the same cycle then repeats itself in 2016-41 (and beyond) as in 1987-2012, then the gold price may be expected to evolve as shown in Exhibit 172, assuming the same discounts and premiums in future years as in the corresponding years of the past cycle (see Exhibit 163). Note that the maximum premium (actual/expected) in the most recent cycle occurred in 2007 (Exhibit 163) and not, as might be expected, in 2012.

**Exhibit 172: Historical and forecast gold price (forecast made with respect to US total monetary base)**



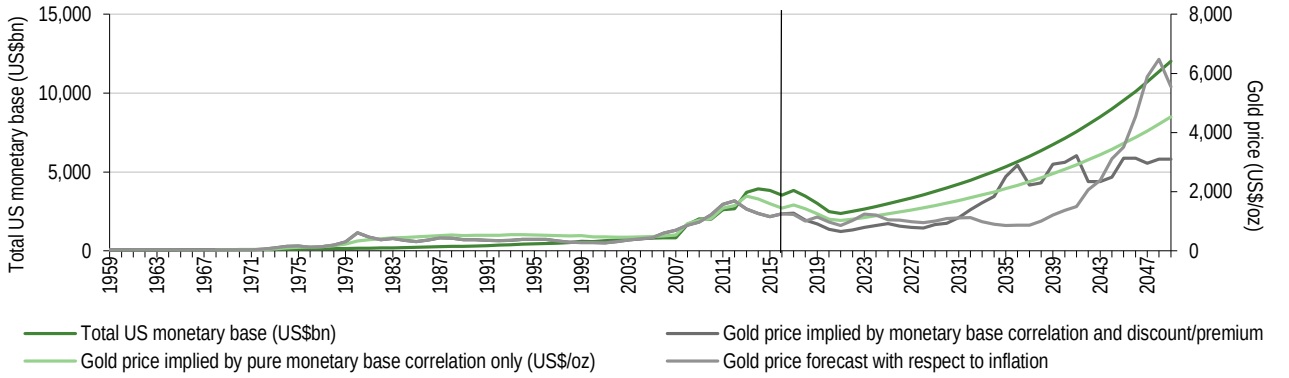

Source: Edison Investment Research and (underlying historical data) Federal Reserve, South African Chamber of Mines, dollardaze.org

Applying the discount thus anticipated for 2017 to the likely level of the total US monetary base at the end of the year implies a gold price of US$1,272/oz – ie close to its actual level at the time of writing. The effect of the Federal Reserve successfully reducing its balance sheet by US$1.48tn, as set out above, and this being reflected in the monetary base however, would suggest that the gold price would fall to US$661/oz in 2021, before recovering to something close to current levels, in nominal terms, a decade later, in 2032.

Such a 39.2% contraction of the monetary base is without precedent in the modern era (at least since 1913) and could be expected to be attended by a deep domestic recession in the US – even if effected over four years – and material downward pressure on prices. In this case however, it may be possible to avert such an outcome if growth in currency in circulation is maintained, such that the reduction is concentrated in commercial banks' reserves held at the Fed, which would then need to decline (according to our estimates) by 88.9% to pre-2008 levels. Ideally, such a contraction of the Fed's balance sheet would leave asset prices largely unchanged and therefore be the logical inverse of the Fed's balance sheet expansion in the period 2007-14 that is largely credited with preventing asset prices from falling (the counterfactual argument being that prices would otherwise rise to levels implied by the monetary base's relationship with inflation in Exhibit 165). Under this scenario, inflation levels would remain contained, which could give rise to three different outcomes for gold:

- The gold price maintains its relationship with the total US monetary base and falls to US$661/oz in 2021, but inflation remains largely unchanged, effectively killing the gold mining industry in all countries that do not devalue their currencies with respect to the US dollar.
- The gold price maintains its historical relationship with inflation, in which case its correlation with the US monetary base moderates. Even under this circumstance however, it is notable that gold prices derived using these two methods converge closely during the period 2017-31, before diverging significantly thereafter:

**Exhibit 173: Historical and forecast gold price (forecast made with respect to 1. US total monetary base and 2. inflation)**




Source: Edison Investment Research and (underlying historical data) Federal Reserve, South African Chamber of Mines, dollardaze.org

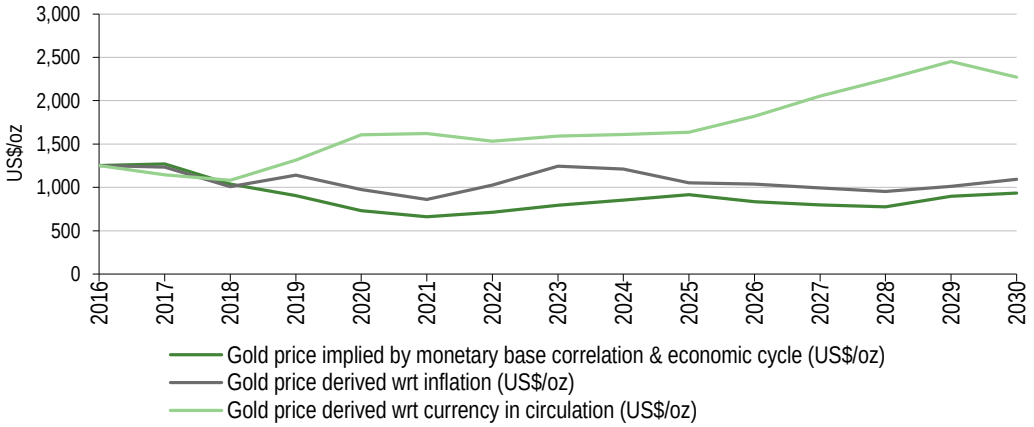
- The gold price could maintain its relationship with currency in circulation (and also therefore, to some extent, with inflation, assuming that the former's upwards only trajectory is maintained), in which case, its correlation with the total US monetary base will similarly moderate.

The alternative, deflationary, scenario is that the contraction of the monetary base causes a contraction in currency in circulation and a simultaneous decline in both the price of gold and the costs of mining gold (see Gold: US$2070 by 2020, published in November 2013 for the historical relationship between gold prices and production costs). In contrast to the first scenario (immediately above), this would maintain gold mining in countries with dollar-denominated or dollar-linked currencies. However, such an outcome would also echo Andrew Mellon's advice to the then President Hoover at the time of the Great Depression to "liquidate labor, liquidate stocks, liquidate farmers, liquidate real estate" and, in our opinion, would prove politically unacceptable to the American polity in general.

## Gold price forecasts

A graphical representation of the three possible outcomes, cited above, is as follows:

**Exhibit 174: Gold price forecast made with respect to 1. US total monetary base, 2. Inflation and 3. US currency in circulation, 2016-30e**




Source: Edison Investment Research and (underlying historical data) Federal Reserve, South African Chamber of Mines, dollardaze.org

In table form, a summary of Edison's gold price forecasts from 2017-30 on the basis of the preceding four analyses is as follows:

**Exhibit 175: Edison forecast gold price range, 2017-24e (US$/oz)**

| | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Currency in circulation | 1,145 | 1,082 | 1,315 | 1,606 | 1,622 | 1,532 | 1,593 | 1,610 | 1,637 | 1,821 | 2,053 | 2,245 | 2,451 | 2,271 |
| Monetary base correlation | 1,555 | 1,424 | 1,256 | 1,069 | 1,025 | 1,076 | 1,131 | 1,188 | 1,249 | 1,314 | 1,383 | 1,456 | 1,533 | 1,615 |
| Inflation | 1,232 | 1,010 | 1,143 | 975 | 860 | 1,027 | 1,243 | 1,213 | 1,053 | 1,040 | 992 | 953 | 1,012 | 1,094 |
| Monetary base correlation & cycle | 1,272 | 1,038 | 907 | 730 | 661 | 712 | 796 | 854 | 918 | 835 | 797 | 776 | 896 | 933 |
| Average | 1,301 | 1,139 | 1,155 | 1,095 | 1,042 | 1,087 | 1,191 | 1,216 | 1,214 | 1,253 | 1,306 | 1,358 | 1,473 | 1,478 |
| October 2016 forecast* | 1,328 | 1,324 | 1,451 | 1,603 | 1,647 | 1,635 | 1,694 | 1,741 | 1,796 | 1,899 | 2,018 | 2,113 | 2,213 | 2,245 |
| October 2016 forecast** | 1,200 | 1,154 | 1,184 | 1,314 | 1,299 | 1,224 | 1,281 | 1,359 | 1,413 | 1,517 | 1,464 | 1,431 | 1,420 | 1,499 |

Source: Edison Investment Research. Note: *Negative real interest rate scenario. **Positive real interest rate scenario.

Two features of this analysis are noteworthy:

- That our November 2017 forecast is much closer to our positive interest rate scenario forecasts of October 2016 than our negative interest rate one (suggesting that this is now the market's expectation).
- Within this context, an average US$101/oz decline in the level of our forecasts, which may be primarily attributable to the Fed's taper plan.

## Gold considered as a currency

Implicitly, the analysis above, which relates the price of gold to inflation and money supply, recognises certain characteristics of gold that render it amenable to analysis as if it were an official currency – which, of course, it was, formally, for centuries and remains so for many millions of people (investors and otherwise) without access to a credible fiat currency alternative and who wish to own it simultaneously as a store of value and also as a medium of exchange. In this case therefore, the future gold price can be explicitly valued relative to the US dollar on the basis of the two entities' respective inflation and interest rates. Initially, the interest rate associated with gold will be assumed to be zero, as the metal is assumed to be bought and held, in physical form, by investors (NB alternatively, it could be considered to be the gold lease rate). Similarly, the inflation rate associated with gold is assumed to be zero, as it is assumed to be purchased by investors precisely on account of its 'real' attributes. This being the case, from a spot price of US$1,279/oz at

the time of writing, the future price of gold in one year's time may be expressed in US dollars, relative to expected future US inflation and US interest rates according to the following table:

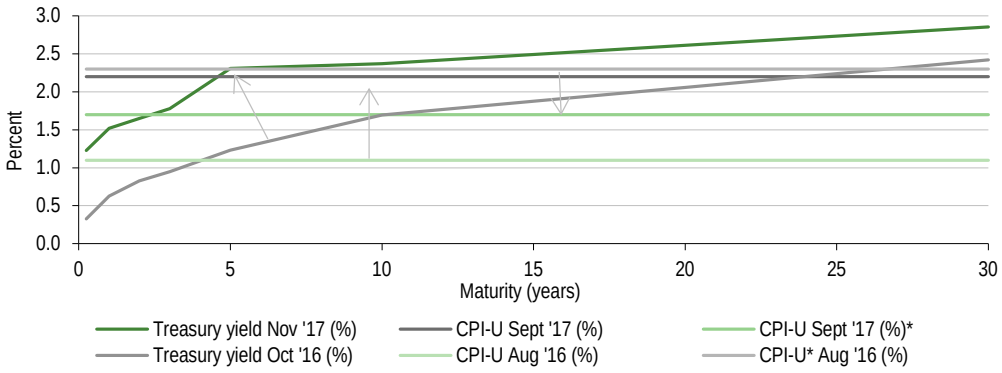
**Exhibit 176: Gold price predicted as a currency with respect to US dollar inflation and interest rate environment over one year**

| US$/oz | Future interest rate (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Future inflation rate (%) | 0.0% | 1.0% | 2.0% | 3.0% | 4.0% | 5.0% | 6.0% | 7.0% | 8.0% | 9.0% | 10.0% |
| (3%) | 1,241 | 1,228 | 1,216 | 1,204 | 1,193 | 1,182 | 1,170 | 1,159 | 1,149 | 1,138 | 1,128 |
| (2%) | 1,253 | 1,241 | 1,229 | 1,217 | 1,205 | 1,194 | 1,182 | 1,171 | 1,161 | 1,150 | 1,139 |
| (1%) | 1,266 | 1,254 | 1,241 | 1,229 | 1,218 | 1,206 | 1,195 | 1,183 | 1,172 | 1,162 | 1,151 |
| 0% | 1,279 | 1,266 | 1,254 | 1,242 | 1,230 | 1,218 | 1,207 | 1,195 | 1,184 | 1,173 | 1,163 |
| 1% | 1,292 | 1,279 | 1,266 | 1,254 | 1,242 | 1,230 | 1,219 | 1,207 | 1,196 | 1,185 | 1,174 |
| 2% | 1,305 | 1,292 | 1,279 | 1,267 | 1,254 | 1,242 | 1,231 | 1,219 | 1,208 | 1,197 | 1,186 |
| 3% | 1,317 | 1,304 | 1,292 | 1,279 | 1,267 | 1,255 | 1,243 | 1,231 | 1,220 | 1,209 | 1,198 |
| 4% | 1,330 | 1,317 | 1,304 | 1,291 | 1,279 | 1,267 | 1,255 | 1,243 | 1,232 | 1,220 | 1,209 |
| 5% | 1,343 | 1,330 | 1,317 | 1,304 | 1,291 | 1,279 | 1,267 | 1,255 | 1,243 | 1,232 | 1,221 |
| 6% | 1,356 | 1,342 | 1,329 | 1,316 | 1,304 | 1,291 | 1,279 | 1,267 | 1,255 | 1,244 | 1,232 |
| 7% | 1,369 | 1,355 | 1,342 | 1,329 | 1,316 | 1,303 | 1,291 | 1,279 | 1,267 | 1,256 | 1,244 |
| 8% | 1,381 | 1,368 | 1,354 | 1,341 | 1,328 | 1,316 | 1,303 | 1,291 | 1,279 | 1,267 | 1,256 |
| 9% | 1,394 | 1,380 | 1,367 | 1,354 | 1,340 | 1,328 | 1,315 | 1,303 | 1,291 | 1,279 | 1,267 |
| 10% | 1,407 | 1,393 | 1,379 | 1,366 | 1,353 | 1,340 | 1,327 | 1,315 | 1,303 | 1,291 | 1,279 |

Source: Edison Investment Research

Within this context, it should be noted that one-year market US interest rates, as calculated from the US Treasury bond with the appropriate maturity, are 1.519% (vs 0.629% in October 2016) and that historical US inflation to September 2017 is 2.2% (vs 1.1% in August 2016), as measured by the CPI for All Urban Consumers (CPI-U), or 1.7% (vs 2.3%), as measured by the core CPI for All Urban Consumers less food and energy, as depicted in the graph below:

**Exhibit 177: US yield curve (%) and inflation rate (%), November 2017 vs October 2016**




Source: Bloomberg, U.S. Bureau of Labor Statistics. Note: *Core rate (less food and energy).

Of note, is the appreciable steepening of the yield curve over the course of the past 13 months, coincident with a rise in headline inflation, if not core inflation core inflation, which nevertheless remains at a relatively high level.

Over four years, time compounds the effect of both US dollar inflation and interest rates on the price of gold:

**Exhibit 178: Gold price predicted as a currency with respect to US dollar inflation and interest rate environment over four years**

| US$/oz | Future interest rate (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Future inflation rate (%) | 0.0% | 1.0% | 2.0% | 3.0% | 4.0% | 5.0% | 6.0% | 7.0% | 8.0% | 9.0% | 10.0% |
| (3%) | 1,132 | 1,088 | 1,046 | 1,006 | 968 | 932 | 897 | 864 | 832 | 802 | 773 |
| (2%) | 1,180 | 1,134 | 1,090 | 1,048 | 1,008 | 971 | 934 | 900 | 867 | 836 | 806 |
| (1%) | 1,229 | 1,181 | 1,135 | 1,092 | 1,050 | 1,011 | 973 | 937 | 903 | 870 | 839 |
| 0% | 1,279 | 1,229 | 1,182 | 1,136 | 1,093 | 1,052 | 1,013 | 976 | 940 | 906 | 874 |
| 1% | 1,331 | 1,279 | 1,230 | 1,183 | 1,138 | 1,095 | 1,054 | 1,015 | 978 | 943 | 909 |
| 2% | 1,384 | 1,330 | 1,279 | 1,230 | 1,183 | 1,139 | 1,097 | 1,056 | 1,018 | 981 | 946 |
| 3% | 1,440 | 1,383 | 1,330 | 1,279 | 1,231 | 1,184 | 1,140 | 1,098 | 1,058 | 1,020 | 983 |
| 4% | 1,496 | 1,438 | 1,382 | 1,329 | 1,279 | 1,231 | 1,185 | 1,141 | 1,100 | 1,060 | 1,022 |
| 5% | 1,555 | 1,494 | 1,436 | 1,381 | 1,329 | 1,279 | 1,231 | 1,186 | 1,143 | 1,101 | 1,062 |
| 6% | 1,615 | 1,552 | 1,492 | 1,435 | 1,380 | 1,328 | 1,279 | 1,232 | 1,187 | 1,144 | 1,103 |
| 7% | 1,677 | 1,611 | 1,549 | 1,490 | 1,433 | 1,379 | 1,328 | 1,279 | 1,232 | 1,188 | 1,145 |
| 8% | 1,740 | 1,672 | 1,608 | 1,546 | 1,487 | 1,432 | 1,378 | 1,327 | 1,279 | 1,233 | 1,188 |
| 9% | 1,805 | 1,735 | 1,668 | 1,604 | 1,543 | 1,485 | 1,430 | 1,377 | 1,327 | 1,279 | 1,233 |
| 10% | 1,873 | 1,800 | 1,730 | 1,664 | 1,601 | 1,541 | 1,483 | 1,429 | 1,376 | 1,327 | 1,279 |

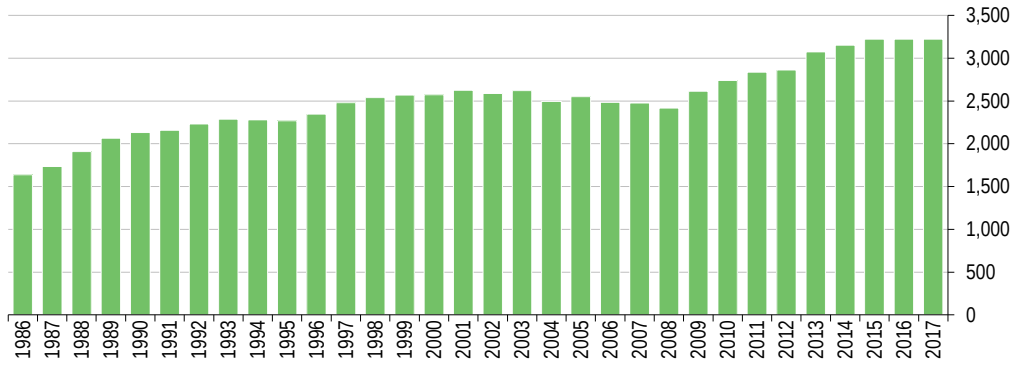
Source: Edison Investment Research

In both cases, investors should note the diagonal line of equivalence (highlighted), at which future interest rates and inflation are the same, such that real interest rates are zero, with the result that there is no expected change in the gold price.

A refinement on the above analysis would be to consider newly mined gold as representing a form of inflation – analogous to monetary inflation as a result of increases in the money supply. All other things being equal, this would be expected to result in a gradual decline in the price of gold with time. However, it should properly be considered within the context of a rising global population, which utilises gold and therefore accords it its value.

In the last 29 years, the annual supply of newly mined gold has doubled, from 1,637t per annum in 1986 to 3,221t in 2015 – equivalent to growth of 2.4% per annum (although it is notable that this appears to occur in distinct waves, arguably lagging a prior price rise) – such that above ground stocks reached an estimated 165,000 tonnes:

**Exhibit 179: World mine supply of gold, 1986-2017e (tonnes)**




Source: South African Chamber of Mines, Metal Focus

Thus, after the gold price last peaked in 2012, there has been a reduction in investment in the sector, combined with an effort to run existing mines at, or near, full capacity to maximise economies of scale and to minimise the effect of fixed costs on unit costs of production. With these two effects having now largely run their course, it seems unlikely that new mines will do any more than fill the shortfall resulting from the natural decay in output from existing operations in the absence of an external stimulus (eg the gold price). All other things being equal therefore, having reached 3,221t, future output is expected to be no more than flat in the immediately foreseeable future (source: Metal Focus) before probably declining modestly thereafter. Relative to initial above

ground stocks of 165,000t, this equates to an initial gold inflation rate (ie acting to deflate the real value gold) of 1.9% in 2017, declining to no more than 1.8% in 2020.

At the same time, global population growth is expected to continue its declining trend, since it peaked above 2% in the early 1960s. In 2017 therefore, it is expected to grow at 0.9917% in 2017 (source: Wikimedia Commons), followed by, 09833% in 2018, 0.9417% in 2019 and 0.9333% in 2020.

Adjusting for these 'real' factors, the future price of gold in one year's time may be expressed in US dollars (again relative to expected future US inflation and US interest rates), according to the following table:

**Exhibit 180: Gold price predicted as currency with respect to the global inflation of 'real' assets as well as US monetary inflation and interest rates (one year)**

| US$/oz | Future interest rate (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Future inflation rate (%) | 0.0% | 1.0% | 2.0% | 3.0% | 4.0% | 5.0% | 6.0% | 7.0% | 8.0% | 9.0% | 10.0% |
| (3%) | 1,229 | 1,217 | 1,205 | 1,194 | 1,182 | 1,171 | 1,160 | 1,149 | 1,138 | 1,128 | 1,118 |
| (2%) | 1,242 | 1,230 | 1,218 | 1,206 | 1,194 | 1,183 | 1,172 | 1,161 | 1,150 | 1,140 | 1,129 |
| (1%) | 1,255 | 1,242 | 1,230 | 1,218 | 1,206 | 1,195 | 1,184 | 1,173 | 1,162 | 1,151 | 1,141 |
| 0% | 1,267 | 1,255 | 1,243 | 1,230 | 1,219 | 1,207 | 1,196 | 1,184 | 1,174 | 1,163 | 1,152 |
| 1% | 1,280 | 1,267 | 1,255 | 1,243 | 1,231 | 1,219 | 1,208 | 1,196 | 1,185 | 1,174 | 1,164 |
| 2% | 1,293 | 1,280 | 1,267 | 1,255 | 1,243 | 1,231 | 1,220 | 1,208 | 1,197 | 1,186 | 1,175 |
| 3% | 1,305 | 1,293 | 1,280 | 1,267 | 1,255 | 1,243 | 1,232 | 1,220 | 1,209 | 1,198 | 1,187 |
| 4% | 1,318 | 1,305 | 1,292 | 1,280 | 1,267 | 1,255 | 1,243 | 1,232 | 1,220 | 1,209 | 1,198 |
| 5% | 1,331 | 1,318 | 1,305 | 1,292 | 1,280 | 1,267 | 1,255 | 1,244 | 1,232 | 1,221 | 1,210 |
| 6% | 1,343 | 1,330 | 1,317 | 1,304 | 1,292 | 1,279 | 1,267 | 1,256 | 1,244 | 1,233 | 1,221 |
| 7% | 1,356 | 1,343 | 1,330 | 1,317 | 1,304 | 1,292 | 1,279 | 1,267 | 1,256 | 1,244 | 1,233 |
| 8% | 1,369 | 1,355 | 1,342 | 1,329 | 1,316 | 1,304 | 1,291 | 1,279 | 1,267 | 1,256 | 1,244 |
| 9% | 1,381 | 1,368 | 1,354 | 1,341 | 1,328 | 1,316 | 1,303 | 1,291 | 1,279 | 1,267 | 1,256 |
| 10% | 1,394 | 1,380 | 1,367 | 1,354 | 1,341 | 1,328 | 1,315 | 1,303 | 1,291 | 1,279 | 1,267 |

Source: Edison Investment Research.

Over four years, it is as follows:

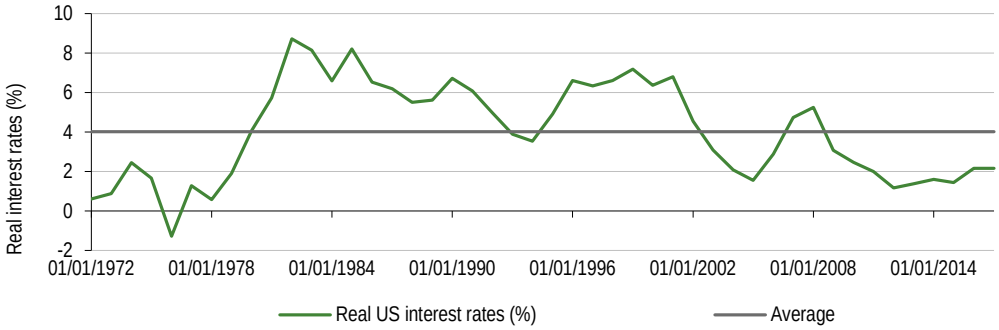
**Exhibit 181: Gold price predicted as currency with respect to the global inflation of 'real' assets as well as US monetary inflation and interest rates (over four years)**

| US$/oz | Future interest rate (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Future inflation rate (%) | 0.0% | 1.0% | 2.0% | 3.0% | 4.0% | 5.0% | 6.0% | 7.0% | 8.0% | 9.0% | 10.0% |
| (3%) | 1,093 | 1,050 | 1,010 | 971 | 934 | 899 | 866 | 834 | 803 | 774 | 746 |
| (2%) | 1,139 | 1,094 | 1,052 | 1,012 | 973 | 937 | 902 | 869 | 837 | 807 | 778 |
| (1%) | 1,186 | 1,139 | 1,095 | 1,054 | 1,014 | 976 | 939 | 905 | 872 | 840 | 810 |
| 0% | 1,234 | 1,186 | 1,140 | 1,097 | 1,055 | 1,016 | 978 | 942 | 907 | 874 | 843 |
| 1% | 1,284 | 1,234 | 1,187 | 1,141 | 1,098 | 1,057 | 1,017 | 980 | 944 | 910 | 877 |
| 2% | 1,336 | 1,284 | 1,234 | 1,187 | 1,142 | 1,099 | 1,058 | 1,019 | 982 | 947 | 913 |
| 3% | 1,389 | 1,335 | 1,284 | 1,234 | 1,188 | 1,143 | 1,100 | 1,060 | 1,021 | 984 | 949 |
| 4% | 1,444 | 1,388 | 1,334 | 1,283 | 1,234 | 1,188 | 1,144 | 1,102 | 1,061 | 1,023 | 986 |
| 5% | 1,500 | 1,442 | 1,386 | 1,333 | 1,283 | 1,234 | 1,188 | 1,145 | 1,103 | 1,063 | 1,025 |
| 6% | 1,558 | 1,498 | 1,440 | 1,385 | 1,332 | 1,282 | 1,234 | 1,189 | 1,145 | 1,104 | 1,064 |
| 7% | 1,618 | 1,555 | 1,495 | 1,438 | 1,383 | 1,331 | 1,282 | 1,234 | 1,189 | 1,146 | 1,105 |
| 8% | 1,679 | 1,614 | 1,551 | 1,492 | 1,436 | 1,382 | 1,330 | 1,281 | 1,234 | 1,190 | 1,147 |
| 9% | 1,742 | 1,674 | 1,610 | 1,548 | 1,489 | 1,433 | 1,380 | 1,329 | 1,281 | 1,234 | 1,190 |
| 10% | 1,807 | 1,737 | 1,670 | 1,606 | 1,545 | 1,487 | 1,432 | 1,379 | 1,328 | 1,280 | 1,234 |

Source: Edison Investment Research.

Note the contrast between the results of Exhibit 175 and Exhibit 181, with our forecast price of gold based on US currency in circulation of US$1,606/oz corresponding to apparent negative real interest rates in the order of 7% (green shading) – which compares to a post-gold standard average real interest rate in the US of (positive) 4.02% since end-1971:

**Exhibit 182: US real interest rates, 1972-2017**




Source: Bloomberg, World Bank

Frankfurt +49 (0)69 78 8076 960
Schumannstrasse 34b
60325 Frankfurt
Germany

London +44 (0)20 3077 5700
280 High Holborn
London, WC1V 7EE
United Kingdom

New York +1 646 653 7026
295 Madison Avenue, 18th Floor
New York, NY10017
US

Sydney +61 (0)2 8249 8342
Level 12, Office 1205, 95 Pitt Street
Sydney, NSW 2000
Australia

Frankfurt +49 (0)69 78 8076960
Schumannstrasse 34b
60325 Frankfurt
Germany

London +44 (0)20 3077 5700
280 High Holborn
London, WC1V 7EE
United Kingdom

New York +1 646 653 7026
295 Madison Avenue, 18th Floor
10017, New York
United States

Sydney +61 (0)2 8249 8342
Level 12, Office 1205, 95 Pitt St,
Sydney NSW 2000
Australia