EDISON

Gold stars and black holes

Analysing the discount: From resource to sanction

Mining sector report, January 2019

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Preface

In keeping with recent tradition, Edison has conducted, augmented and added to three major analyses in this report. The first is to derive in-situ vales for 19 metals and minerals, listed across three markets, differentiated by resource category. The second is a study of EV/NPV ratios for junior explorers at PEA, PFS and BFS stages of development. The third is a series of multiple regression analyses used to both corroborate our in-situ valuations and to derive specific empirical equations to predict the valuations of junior mining exploration companies with respect to five factors, namely project location, IRR, NPV, discount rate and stage of development.

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Metals & mining

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'If a man empties his purse into his head, no man can take it away from him. An investment in knowledge always pays the best interest.'
Benjamin Franklin, statesman

Edison has once again taken the opportunity to analyse the global equity markets' appetite for pre-production mining companies. This report highlights our findings:

Explorers benefit from forward-looking investors

Overall, the market appears to be ascribing less in-situ value for pre-development resources than it did in 2017. This is largely following commodity price movements but with a few notable exceptions such as vanadium.

On a more positive note for junior mining companies, many of the commodities are showing in-situ value accretion when moving projects from inferred through to measured resources. This includes gold, a number of the in vogue battery metals (vanadium, lithium) and also – slightly unusually – some of the bulk commodities such as coal (thermal and met). However, commodities where we see there is uncertainty around demand (eg uranium, copper, zinc) may experience valuation pressures as projects reach the measured resource stage but then potentially struggle to attract funding. Companies need to bear these trends in mind when considering deploying additional expenditure to upgrade resources.

On the other hand, equity markets' tendency to ascribe value to companies they expect to increase resources appears to be increasing – another positive for early stage exploration companies seeking capital. The markets also appear to be less concerned by political risk than they have previously, although there is strong evidence this becomes more important ahead of project sanction.

Finally, breaking the markets down (in this case for gold), it appears that Australia continues to offer the greatest recognition for pre-development resources ahead of London (especially at the inferred and indicated stages). In the meantime, the Canadian market continues to be a sensible home for early stage companies, although valuations struggle versus other markets as resources are matured.

While developers need to target BFS as a priority

Equity markets remain tough for companies looking to develop projects through to sanction. The markets continue to discount PEA-stage projects significantly (even more so than in 2017) and as in 2017 we see value destruction at the PFS stage. While there are always exceptions, it appears prudent for companies to focus on getting to BFS stage as expeditiously as possible, as that is where equity markets offer valuations that reflect anything like the NPV of the underlying projects.

Development companies should also consider the factors that will influence equity valuations. Increasingly, markets reward projects of scale and low sovereign risk as they approach sanction, while overall project economics (IRR) becomes less important. Perhaps surprisingly, grade appears to be less important than we had previously thought. Ultimately, the right projects should be sanctioned, although it is important for companies not to get bogged down in equity market 'black holes' and focus on moving resources through to BFS as expediently as possible.

Analyst

Charles Gibson +44(0)20 3077 5724

mining@edisongroup.com

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Executive summary

In past publications, we have 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). In addition to our traditional in-situ analysis, in 2018, Edison conducted multiple regression analyses over 12 of the 19 metals/minerals across three markets that were the subject of the in-situ analysis in order to corroborate (or not) the findings of the in-situ study.

For only the second time, we have also performed an EV to project NPV analysis. In this case however, rather than being conducted over a limited sample of 63 companies and five metals and minerals, the study has been conducted over a sample of 102 companies, 13 metals and minerals and three distinct stages of development, 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 seven project variables (NPV, grade, IRR, size, jurisdiction, discount rate and product) and the valuations of their host operating companies.

Gold

Results for gold explorers, including the variance in calculated values from our previous report on the subject (Mining overview: Unlocking the price to NPV discount, published in November 2017), are provided in the table below. Results for the whole suite of metals and minerals analysed are given in Exhibit 2 on page 5.

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

	July 2018				July 2017				Variance (%)			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
London market	61.19	8.68	7.87	9.88	17.88	10.27	7.33	10.34	242.2	-15.5	7.4	-4.4
Canadian market	29.12	13.82	7.87	13.83	47.49	6.92	11.64	15.68	-38.7	99.7	-32.4	-11.8
Australian market	62.88	24.84	7.87	24.08	98.57	36.58	7.33	31.27	-32.1	7.4	-23.0	-32.1
Arithmetic mean	**51.06**	**15.78**	**7.87**	**15.93**	**54.65**	**17.92**	**8.77**	**19.10**	**-6.6**	**-11.9**	**-10.3**	**-16.6**
Geometric mean	**32.78**	**12.33**	**11.07**	**14.95**	**43.70**	**12.89**	**11.00**	**17.54**	**-25.0**	**-4.3**	**0.6**	**-14.8**

Source: Edison Investment Research

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

- Globally, the average value of an average ounce has declined by 14.8% compared to that in July 2017, at a time when the gold price has declined by 1.6% (US$1,208/oz vs US$1,228/oz).
- The 'logical' pattern, whereby the value of measured ounces is greater than the value of indicated ounces, which is greater than the value of inferred ounces, has reasserted itself across all three markets, as well as the arithmetic and geometric means. Among other things, this means that investment returns from delineating an average resource are positive in all three markets for the first time in five years (see Exhibit 26).
- The average value of ounces quoted in the London market is lower than that observed in the other two markets for the second year in succession.
- The average value of ounces quoted in the Australian market is above that observed in London and Canada for the third year in succession.
- Against an otherwise prevailing negative trend, the (implied) values for measured ounces in London and indicated ounces in Canada have increased.
- Valuations overall remain consistent with bear market conditions, generally (see Exhibit 141 on page 69).

In-situ valuation summary

Exhibit 2: Selected metals' and minerals' in-situ values, costs of discovery, etc, 2018

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	61.19	29.12	62.88	32.78	51.06	-0.65	-3.67	0.044	-269.56	144.18	-25.81	0.038	0.165	-6.58	4.40	-0.40	2.83	213.26	622.60	130.16	308.80	-10.83	6.47
Indicated	8.68	13.82	24.84	12.33	15.78	0.25	1.52	0.060	99.10	16.68	7.77	0.030	0.065	1.70	0.57	0.20	8.08	117.99	294.30	34.55	216.45	10.73	1.80
Inferred	7.87	7.87	7.87	11.07	7.87	1.29	0.22	0.021	11.87	4.51	3.61	0.015	0.019	0.41	0.57	0.003	7.23	8.48	154.27	34.55	216.45	2.80	-0.26
Total/Average	9.88	13.83	24.08	14.95	15.93	0.44	0.46	0.043	22.50	19.75	2.00	0.030	0.055	0.76	0.78	0.020	6.79	52.31	272.29	53.84	222.61	3.41	-0.03
Spot price	1,208	1,208	1,208	1,208	1,208	15.84	25.73	69.09	5,882	12,982	791	118	170	600	600	216	2,650	45,203	33,500	15,570	15,570	1,750	41.00
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	5.07%	2.41%	5.20%	2.71%	4.23%	-4.10%	-14.29%	0.06%	-4.58%	1.11%	-3.26%	0.03%	0.10%	-1.10%	0.73%	-0.18%	0.11%	0.47%	1.86%	0.84%	1.98%	-0.62%	15.78%
Indicated	0.72%	1.14%	2.06%	1.02%	1.31%	1.56%	5.92%	0.09%	1.68%	0.13%	0.98%	0.03%	0.04%	0.28%	0.10%	0.09%	0.30%	0.26%	0.88%	0.22%	1.39%	0.61%	4.38%
Inferred	0.65%	0.65%	0.65%	0.92%	0.65%	8.12%	0.87%	0.03%	0.20%	0.03%	0.46%	0.01%	0.01%	0.07%	0.10%	0.00%	0.27%	0.02%	0.46%	0.22%	1.39%	0.16%	-0.63%
Total/Average	0.82%	1.14%	1.99%	1.24%	1.32%	2.78%	1.80%	0.06%	0.38%	0.15%	0.25%	0.03%	0.03%	0.13%	0.13%	0.01%	0.26%	0.12%	0.81%	0.35%	1.43%	0.19%	-0.06%
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	**0.73%**	**0.73%**	**0.73%**	**0.73%**	**0.73%**		**3.97%**				**0.11%**												
Return on upgrade																							
Measured	99.5	-41.9	44.5	-22.3	34.0		-1,255.1				-1,249.7												
Indicated	-75.7	78.2	408.0	-62.4	136.8		56.6				1,053.3												
Inferred	10.0	10.0	10.0	54.7	10.0		148.5				301.6												
Number of companies	7	36	23	66	66	11	25	20	20	10	3	6	6	4	3	6	10	3	6	9	4	14	2

Source: Edison Investment Research. Note: Platinum equivalent (PtE) costs of discovery derived from Witwatersrand gold cost of discovery. August 2018.

Exhibit 3: 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.

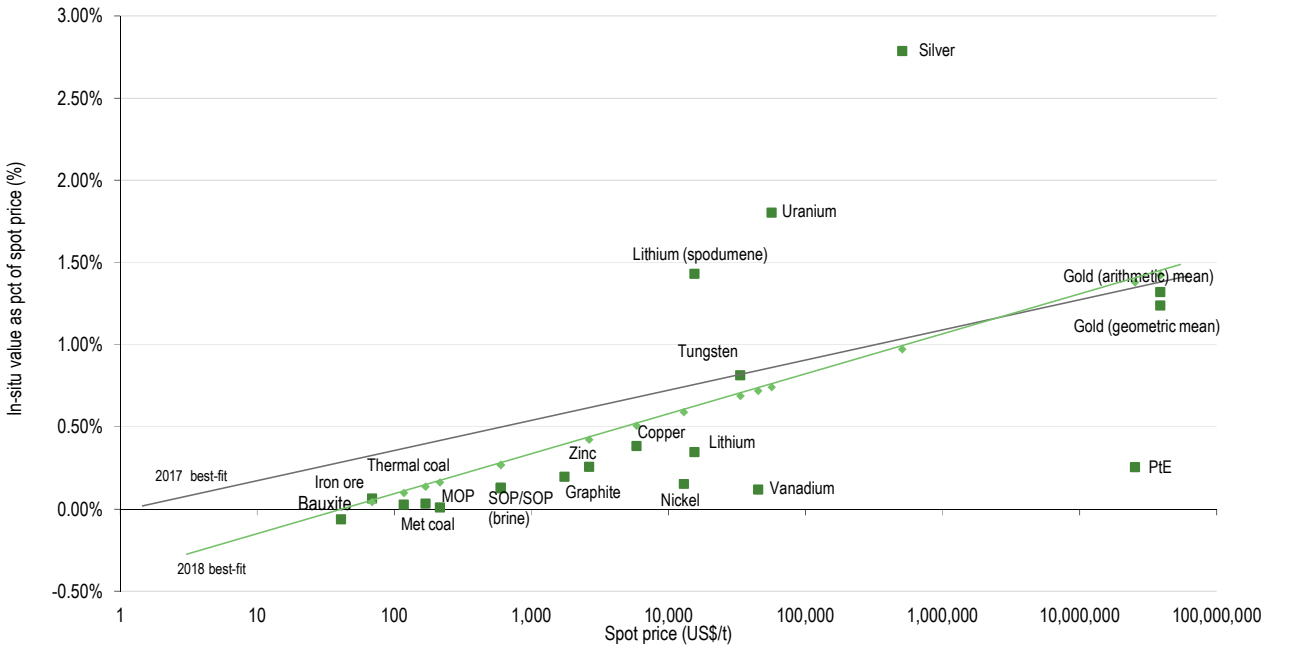
Financial returns from gold exploration

The investment return from drilling an 'average' 1Moz gold resource is positive to varying degrees for gold assets listed across all three markets, albeit barely in the case of the Canadian market (see Exhibit 26). However, there is tangible evidence that, for a non-average deposit, both the London and Australian markets are prepared to afford value for blue-sky potential. Note that this may also be true of the Canadian market as well, albeit the statistical evidence is more equivocal for gold.

Elsewhere however, there is statistical evidence for markets discounting blue-sky potential for every single other metal and mineral in this report (to greater or lesser extents) with the single exception of uranium (which has nevertheless strongly exhibited this characteristic in the past).

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 there is a statistically significant relationship between the logarithm of the price and the in-situ value of the metal/mineral in the graph above (at the 5% level), albeit there are obvious outliers. Otherwise, the best fit line in 2018 is appreciably steeper than the equivalent line in 2017, such that companies with deposits of metals or minerals with a spot price below US$46.41/t (cf US$1.43/t previously) may not now expect to be afforded an in-situ value for their resources.

Equity markets are discounting future movements in commodity markets

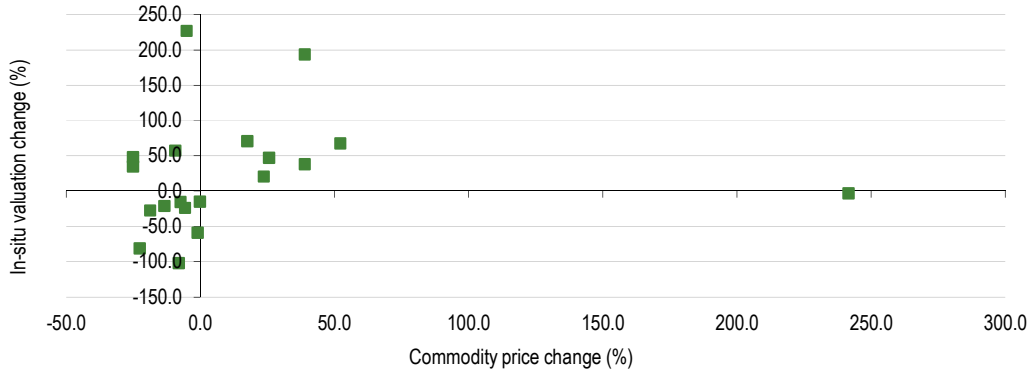
Of the 17 distinct metals and minerals profiled (note: SOP and lithium appear twice as SOP and SOP [brine] and lithium and spodumene lithium, respectively), the prices of six (lithium, thermal coal, tungsten, uranium, nickel and vanadium) have increased since our last note on the subject (Mining overview: Unlocking the price to NPV discount, published in November 2017). In the same timeframe, the prices of 10 (metallurgical coal, copper, SOP, gold, silver, iron ore, platinum, MOP, zinc and bauxite) have declined, while one (graphite) is ostensibly unchanged.

By contrast, the in-situ values of 10 metals and minerals (namely metallurgical coal, thermal coal, tungsten, copper, SOP, uranium, lithium, spodumene lithium, brine and nickel) have increased

between August 2017 and August 2018, while the in-situ values of nine (vanadium, graphite, gold, silver, iron ore, platinum, MOP, zinc and bauxite) have declined.

Owing to different magnitudes of increase and decrease however, on average, in-situ values for the whole range of metals and minerals increased by 23.6%, while prices for those same metals and minerals increased by an average of 16.8%. For each metal or mineral, the change in price and in-situ value since 2017 is shown in the exhibit below:

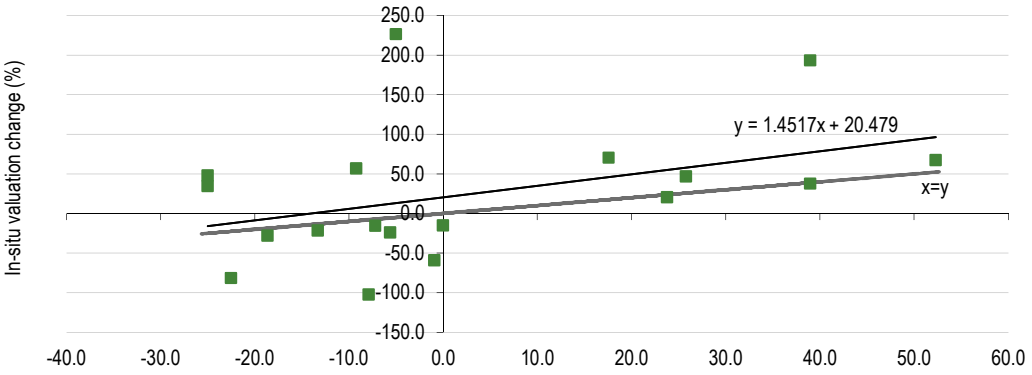
Exhibit 5: In-situ value change (%) vs price change (%) for metals/minerals profiled in this report, 2018 vs 2017



Source: Edison Investment Research

At first glance, there is no statistically significant relationship (at the 5% level) between the commodity price change of the metal/mineral in question and its in-situ valuation over the course of the past year. However, this seems counter-intuitive. Moreover, from a statistical perspective, the data set is unduly influenced by the data point to the far right of the graph (vanadium, which experienced almost no change in in-situ valuation over the period in question, despite a very large increase in the price of vanadium pentoxide, V_2O_5,). If this data point is removed from the data set, then the relationship between the two does become statistically significant:

Exhibit 6: In-situ value change (%) vs price change (%) for metals/minerals profiled in this report (vanadium removed), 2018 vs 2017



Source: Edison Investment Research

Note the implication, from the line of best-fit, that:

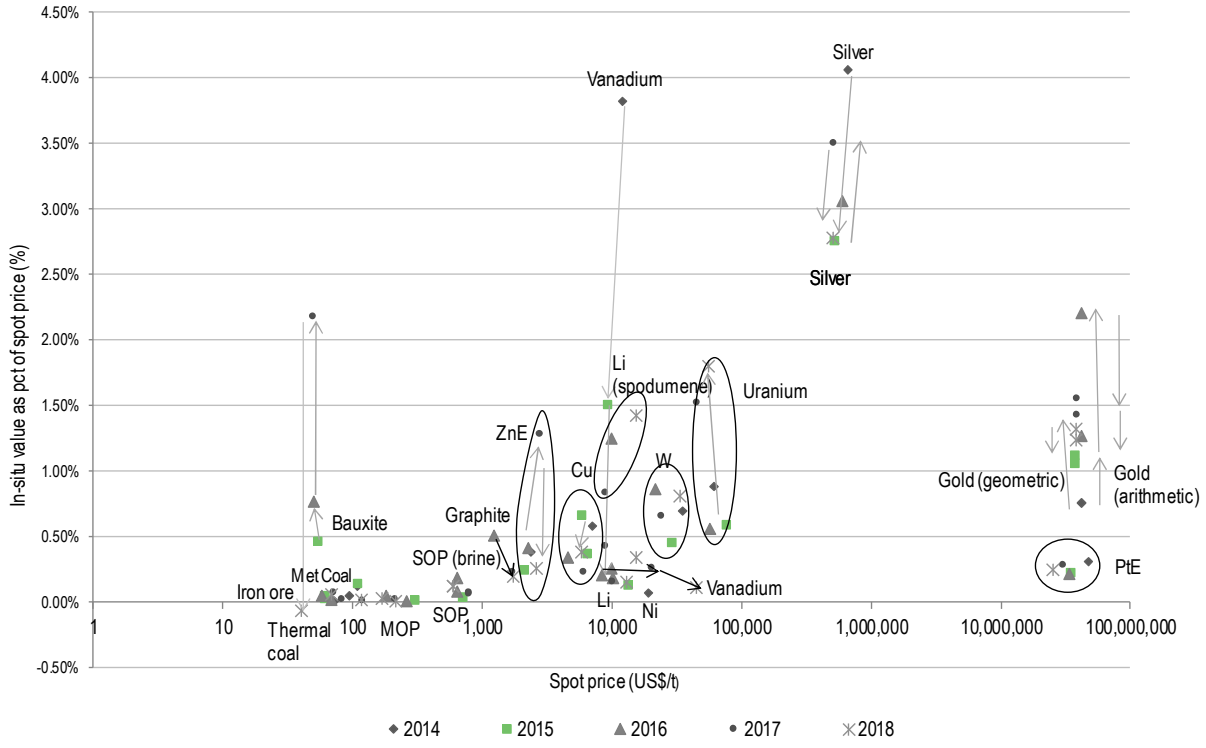
- A 10% move in the commodity price would be expected to be accompanied by a 14.5% move in in-situ value (from whichever point on the graph a metal/mineral occupies).
- A zero percent move in the price of the commodity during the year would still have been expected to have been accompanied by a 20.5% increase in in-situ valuation – arguably indicating a 'bullish' sentiment among investors, if not for all mining assets, certainly strongly across a few assets, or asset classes.

Notable performances were exhibited by:

- Both copper and metallurgical coal, which experienced rising in-situ values over the course of the year, despite falling product prices, arguably indicating that the equity markets are anticipating higher future commodity prices.
- Vanadium, which (as noted previously) experienced a decline (albeit very small) in in-situ value, despite an extremely strong price performance over the course of the year.

Relative to their historical prices and in-situ values (expressed as a percentage of product price) since 2014, changes in-situ values over the course of the past year may alternatively be depicted, as follows:

Exhibit 7: In-situ resource values vs spot prices, selected metals and minerals, 2014–18



Source: Edison Investment Research

Within this context, notable performances were recorded by:

- Bauxite: the in-situ value of bauxite has fallen to approximately where it would be expected to be, given its price and market conditions.
- Zinc: the in-situ value of zinc has returned to approximately where it would be expected to be, given its price and market conditions, after achieving an unusually large valuation relative to its peers in 2017 (although note, not an unusually large valuation relative to history; see Exhibit 141).
- Vanadium: the in-situ price of vanadium declined (albeit modestly) in percentage terms, despite a sharp rise in the price of vanadium (in the form of vanadium pentoxide).
- Uranium, which maintained (and even extended) its premium rating, arguably indicating that the equity markets are continuing to anticipate a further increase in the price of the commodity.
- Platinum: the sample of companies included in the analysis changed markedly and, for the very first time, failed to include any companies operating on South Africa's Bushveld Complex. Despite this however, platinum equivalent valuations (encompassing precious, but not base metal, by-products) have remained largely unchanged – suggesting that companies in this sub-sector suffer from the (low) valuation benchmarks created by their peers in the Bushveld but fail to benefit from the geological implications (including costs of discovery) of operating there.

- Silver, which, although trading at a relatively low historical value relative to its spot price, has continued to maintain its persistent premium rating relative to the broader universe of other metals and minerals, which Edison attributes to the high levels of by-products typically associated with it geologically (eg lead and zinc).

Valuation pitfall of 'over-exploring'

A number of metals and minerals exhibit a discounted valuation for measured resources relative to indicated ones. Whether or not this reflects the 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 now encompasses uranium, silver, iron ore, PGMs, SOP, MOP, copper, zinc and graphite. The reason – or reasons – for this apparent anomaly are a matter for conjecture. In Edison's opinion, it could reflect something as simple as certain commodities (eg uranium, copper, PGMs, MOP) simply being out of favour with equity markets. Alternatively, it could reflect a market judgement that earlier stage indicated and inferred resources are imbued with more valuation optionality than measured one. It could also reflect the effect on the share prices of companies with measured resources of a prolonged and unsuccessful period of project funding. Equally, it could be a combination of these and/or they could be related. More conventional metals/minerals, for which it is apparently still value-adding to delineate measured resources (depending on cost), include gold, nickel, SOP brine, lithium, spodumene lithium, tungsten, vanadium, metallurgical coal, thermal coal and bauxite.

Equity markets provide a fertile environment for prospective ground

In contrast to earlier periods, equity markets now demonstrate the widespread discounting of future exploration success for all but one of the metals and minerals profiled in this report. However, the exception is uranium, which has exhibited this characteristic strongly in the past.

In contrast to last year (when two metals, namely zinc and ASX-listed gold, fell into this category), in 2018 no metals exhibited a positive correlation between resource size and in-situ valuation – ie the larger the resource, the higher the in-situ resource multiple.

Sovereign risk abating

Notwithstanding the above conclusions, in-situ market valuations continue to be consistent with bear market, rather than bull market, conditions (see Exhibit 141). One area in which risk may be perceived to be abating however, is that of sovereign risk (as measured by the Fraser Institute index of Investment Attractiveness). In this report, Edison has calculated limits for risk tolerance among investors by three different methods and concluded that, in a worst-case scenario, they would not be prepared to invest in an 'average' project in a jurisdiction that scores less than 46.62 on the Fraser Institute Investment Attractiveness Index – effectively excluding the bottom 12 jurisdictions in its most recent survey of mining companies. This compares with 29 such jurisdictions that were effectively excluded in our equivalent analysis last year.

Multiple regression analysis corroborates majority of in-situ findings

As indicated earlier, in addition to our traditional in-situ analysis, in 2018, Edison conducted multiple regression analyses over 12 of the 19 metals/minerals across three markets that were the subject of the in-situ analysis. In each case, the analysis was performed between the EVs of the companies included in the report and their resources, broken down by category (ie measured, indicated and inferred). In simple terms, the analysis posits that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots the sample companies' EVs against their measured, indicated and inferred resources (effectively in four

dimensions) and then generates the formulae for the best-fit lines between the points. Of the 12 multiple regression analyses performed:

- One (for uranium) strongly endorsed the findings of the in-situ analysis.
- Six (for London-listed gold, silver, nickel, zinc, tungsten and metallurgical coal) partially endorsed the findings of the in-situ analyses. That is to say, they tended to agree, qualitatively, in identifying the resource categories that could add most value to junior exploration companies' valuations, but not necessarily to the extent implied by the associated in-situ analyses.
- Two (ASX- and TSX-listed gold) generated results that were inconsistent with the associated in-situ analyses.
- Three (MOP, copper and thermal coal) generated results that contradicted the findings of the associated in-situ analyses.

One further feature of the multiple regression analyses is that, unlike the in-situ analyses (that implicitly imply that a company with no resources has no enterprise value), they generate a 'constant' in the formulae of the equations that describe the valuations of the companies analysed. Often, this is close to zero, which would be expected, and merits little discussion. Two notable exceptions however are uranium (which has a large negative constant) and silver and nickel (which have large positive constants). Whereas there is a reasonable degree of doubt surrounding the magnitude of the constant relating to the uranium explorers, statistically speaking, there is much less doubt regarding the constants relating to the nickel and silver explorers. The implication of these constants is that aspiring uranium companies need to come to the world's equity markets with a material resource (all other things being equal) to be accorded any value whatsoever. By contrast, entrepreneurs looking to bring aspiring nickel and silver companies to the world's equity markets can do so with no resources whatsoever and may still be accorded a material valuation in the form of their EVs.

EV/NPV analysis confirms PFS valuation discount

For the second time in two years, Edison has performed a mass EV to project NPV analysis. In this case however, rather than being conducted over a limited sample of 63 companies and five metals and minerals, the study has been conducted over a sample of 102 companies, 13 metals and minerals and three distinct stages of development, 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 seven project variables (NPV, grade, IRR, size, jurisdiction, discount rate and product) and the valuations of their host operating companies.

In conducting our analysis, we concluded that the 'average' project has a published NPV of US$649m (cf US$433m previously) and an average IRR of 40.1% (cf 43.2% previously). Compared with last year however, valuations have contracted – in particular for companies with projects at PEA and PFS stage, although they have largely held up for companies at BFS stage. As before, the distribution of valuations relative to project economics is extremely skewed to the right (see pages 78–83), which renders mean values of very limited use in analysing individual companies. Strikingly however, the apparent 'anomaly', whereby valuations are lower for companies with projects at PFS stage than they are for companies with projects at PEA stage, has persisted since last year, leading Edison to conclude that it is not, in fact, an 'anomaly', but an enduring feature of the market (at least for now):

Exhibit 8: Company EV as percentage of attributable project NPV (%), by study type, statistical summary

	2018						2017					
	Minimum	Mode interval	Mean (excl outliers)	Mean	Maximum	Range	Minimum	Mode interval	Mean (excl outliers)	Mean	Maximum	Range
PEA	-24.3%	0–10%	11.7%	24.1%	154.2%	178.5%	-13.1%	0–10%	18.9%	54.0%	427.1%	440.2%
PFS	-15.4%	0–10%	9.9%	18.2%	202.9%	218.3%	-13.4%	10–20%	16.3%	25.4%	134.8%	148.2%
BFS	-10.1%	10–20%	30.9%	66.5%	524.4%	534.5%	2.6%	10–40%	29.6%	66.6%	428.3%	425.7%
All studies	**-24.3%**	**0–10%**		**33.1%**	**524.4%**	**548.7%**	**-13.4%**	**0–10%**		**52.4%**	**428.3%**	**441.7%**

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

Part of the contraction of valuations at PFS stage may be explained by an apparent simultaneous contraction of IRRs at PFS stage. Why the EV/NPV multiple should contract at the same time is, again, a matter for conjecture at the current time. In Edison's opinion however, it could reflect the market reaction to the lower IRRs from the project then being superimposed upon a necessarily lower NPV (all other things being equal). Whatever the reason though, companies should be aware of this particular market characteristic.

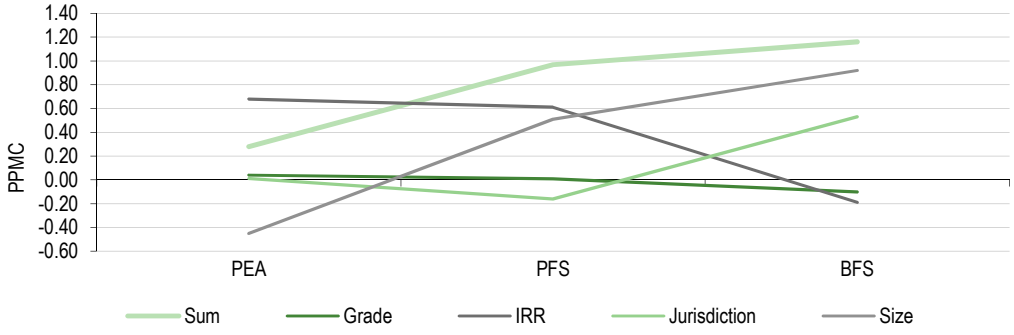
Grade, jurisdiction, IRR and project size

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

- As in 2017, IRRs remain very important to companies' valuations at early-stage, PEA level projects, but become less so as the project is developed through to BFS.
- Jurisdiction has become more important to company valuations at BFS stage in 2018 than in 2017.
- Unlike in 2017, project size appears to be very important in contributing to valuations for companies at BFS stage. However, as in 2017, project resource size actually appears to detract from companies' valuations at earlier stages of development.
- In contrast to 2017, investors in 2018 appear to regard grade as much less important in contributing towards a company's valuation. This could be an anomaly or could be regarded as evidence that gold investors, in particular, may be moving away from the erstwhile mantra of 'grade, grade, grade' – not least because, from a statistical perspective, there is a poor relationship between projects' grades and their IRRs.

A summary of Edison's ultimate assessment of the contribution of each of these four variables to the valuations of junior exploration companies (as measured by the Pearson product moment correlation coefficient between the variable and companies' valuations at different stages of development) is as follows:

Exhibit 9: Graph of PPMC vs stage of development for four factors influencing valuation, 2018 (final)

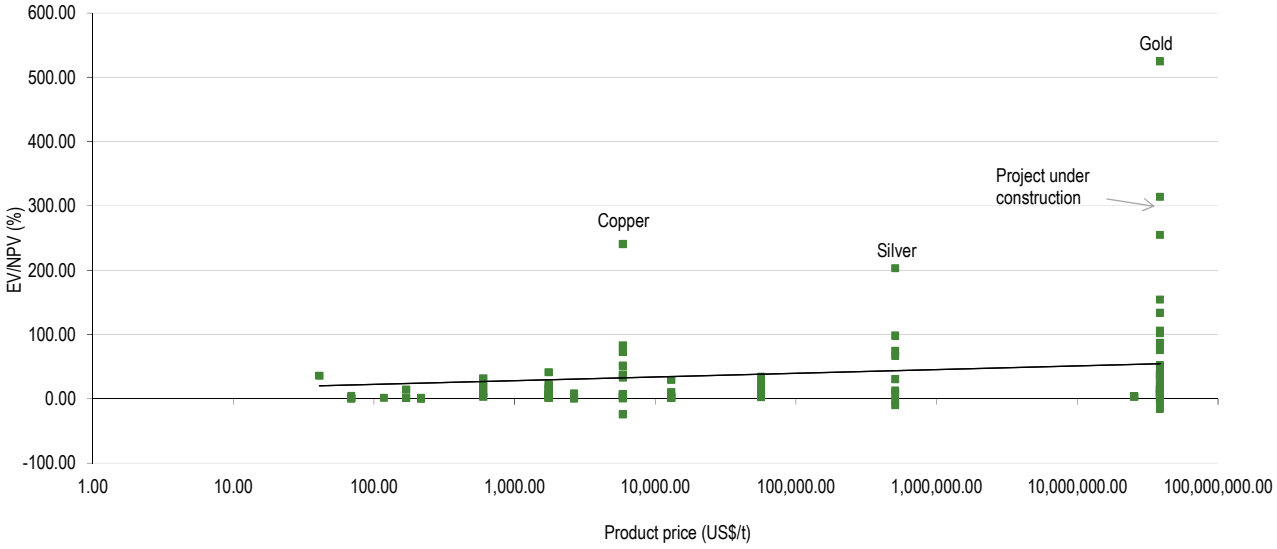


Source: Edison Investment Research

Marked market preference for gold, silver and copper

One additional analysis conducted by Edison in 2018, which was not performed in 2017, was to look at the effect of a project's main product on company valuations. In this case, the resulting scattergram is as follows (note that each 'column' effectively represents a different metal or mineral):

Exhibit 10: Graph of product price (US$/t) vs EV/NPV (%), whole sample



Source: Edison Investment Research. Note: From left to right, columns represent bauxite, iron ore, thermal coal, met coal, MOP, SOP, graphite, zinc, copper, nickel, uranium, silver, platinum, gold.

While the overall Pearson product moment correlation coefficient between price and valuation is low, at 0.24, and not statistically significant at the 5% level, given the amount of data points in the sample, the positive gradient of the best-fit line suggests that the higher the metal price, the higher the valuation, on average. In addition, we have marked out three 'columns', namely copper, silver and gold, for which not only the size of the average valuation, but also the range of potential valuations appears much larger than for other metals/minerals. Subjectively speaking, we do not believe that it is a coincidence that the potential valuation ranges for what are probably the best-known and best-followed metals within the sector are wider than for the remainder of the metals and minerals in our sample. By the same token however, we also cannot help observing the corollary of this argument, which must be that some of the biggest opportunities for investors may lie in metals and minerals with which investors are less familiar.

Management

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 (jurisdiction, geology, engineering, metallurgy, financing and management), we would posit that it is the last – management – that is likely to be responsible for a disproportionate valuation relative to the tangible and financial characteristics of a project. Within that context, it can be seen that, in 2018, the EV of a company at PFS and/or BFS stage can (apparently) be explained almost exclusively in terms of its IRR and size. At the earlier PEA stage however, there is a significant gap between the contribution that the tangible risk factors of a project make towards a company's valuation and its actual valuation. It is at this point therefore that we would assert that the contribution of management to a junior's valuation is at its most critical.

Rationalising EV/NPV with discount rates

We first introduced differentiated market derived discount rates for companies at different stages of development in our 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 11: 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 12: NonSuch Gold EV as a percentage of project NPV, by stage of development

Percent	Scoping study/PEA	PFS	BFS
Maximum	51.9	77.0	116.2
Mid	2.7	12.2	26.4
Minimum	-7.7	-3.3	2.3

Source: Edison Investment Research

These may be directly compared with those percentages derived from our EV/NPV analysis in Exhibit 13, presented below, transposed for easier comparison:

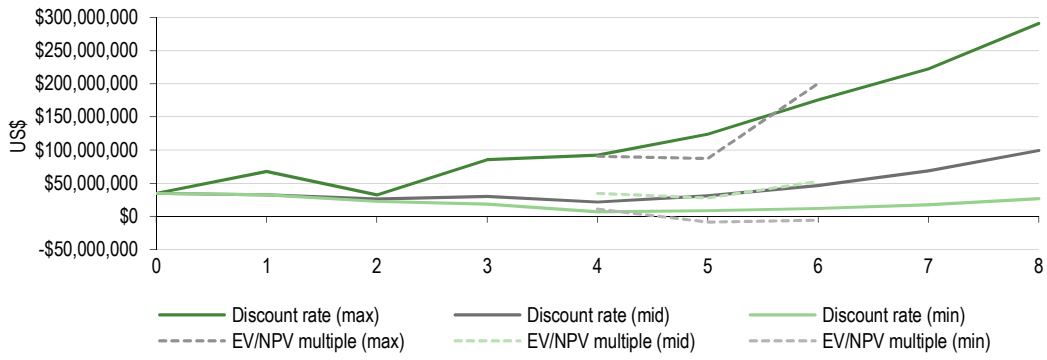
Exhibit 13: Company EV as a percentage of attributable project NPV (%), by study type, ordinarily valued companies, excluding statistical outliers

Percent	Scoping study/PEA	PFS	BFS
Maximum	50.7	51.3	133.5
Mean	11.7	9.9	30.9
Minimum	-4.8	-15.4	-10.1

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 14: 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.

We believe that the results of these two distinct methods for valuing development stage projects are mutually reinforcing and that the valuation benchmarks summarised in Exhibits 12 and 13 (and also Exhibits 194 and 203) may therefore be used with confidence in assessing the value of mining projects and/or junior mining companies – particularly for higher rated companies at earlier stages of development.

Honing the EV/NPV analysis

Edison's EV/NPV analysis described above uses NPVs calculated at a variety of different discount rates. In addition to this analysis, for the first time, in 2018, Edison also conducted an analysis based on the NPVs calculated at a discrete discount rate – in this case 8%, which (from our analysis) proved to be the most commonly used discount rate, accounting for the majority of technical documents studied, as shown below:

Exhibit 15: Discount rates at which EV/NPV analysis conducted

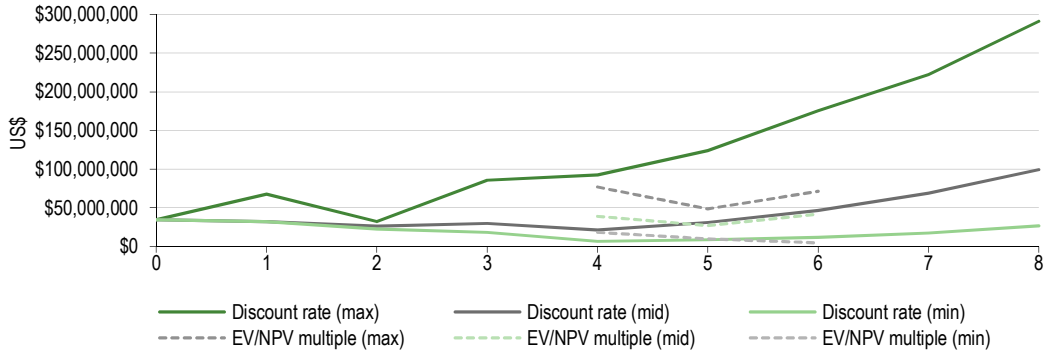
Discount rate (%)	5%	6%	6.5%	7%	7.5%	8%	9%	10%	11%	12%	Total
Number of companies within sample	26	0	1	3	4	55	0	12	0	1	102
Percentage of total (%)	25.5	0.0	1.0	2.9	3.9	53.9	0.0	11.8	0.0	1.0	100.0

Source: Edison Investment Research, company data

In all other respects the EV/NPV analysis performed by Edison on the discrete 8% discount rate sample was identical to that performed on the broader sample of studies conducted with NPVs calculated at a variety of discount rates. As a 'purer', if smaller, sample, it honed and improved some of the findings that were presented in Exhibit 14, above.

However, the main conclusion of this piece of work was that, while valuation predictions based on the parameters defined by the broader sample (see Exhibit 13, above) were more accurate for companies at the top of the valuation range and at earlier stages of development, valuation predictions based on the parameters defined by the discrete 8% discount rate sample were more accurate for companies with valuations towards the average and lower end of the range and at later stages of development:

Exhibit 16: NonSuch Gold valued with respect to 1) discount rates and 2) EV/NPV multiples (based on parameters defined from discrete 8% discount rate sample), compared (US$)



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

Note that the feature, whereby the valuation range is narrower and the mean lower for PFS compared to PEA level projects persists in this analysis (using the 8% sample), as well as for that using the whole sample.

Otherwise, the most important conclusion of this analysis is that, at various stages of development and various points in the valuation range, the market is, to some extent, 'discount rate blind'. An alternative way of expressing this is that the market is more accepting of the discount rates chosen by the operating companies themselves at earlier stages of development (and higher valuation ranges), but that it becomes more discerning at later stages of development (and lower valuation ranges) and requires that an appropriate discount rate is applied.

Parthian shot

In keeping with the rest of this report, in 2018, Edison also performed a simultaneous multiple regression analysis between the EVs of the companies included in the EV/NPV analysis and a

number of factors that are presumed to influence their valuations. In simple terms, the analysis asserts that a company's EV should be a function of these factors and the multiple regression analysis therefore plots EVs of the companies analysed against these factors and then calculates the best-fit line between the points.

Edison performed this analysis twice. In the first instance (1), the analysis included five factors presumed to influence valuation, namely jurisdiction (as measured by the Fraser Institute index of Investment Attractiveness), IRR, stage of development (ie PEA, PFS and BFS), NPV and discount rate. The second (2) included all of the same factors with the exception of the discount rate.

(1) In the case of all five factors, the formula generated by the multiple regression analysis for calculating a company's EV could be stated as follows:

EV = 264.9 + (0.09 × Fraser) + (0.5 × IRR) + (0.04 × NPV in millions) − (2.4 × study type) − (30.8 × discount rate)

The results should probably be taken with a pinch of salt. A plot of the residuals suggests a high degree of heteroscedasticity. This could be interpreted as evidence of a missing variable (possibly management) and/or that one or more variables require transformation to improve the mathematical model. Moreover, self-evidently, NPV and discount rate are not independent of one another, which raises issues of multicollinearity within the analysis. Nevertheless, without going into the details unnecessarily, suffice it to say that there is a good level of confidence surrounding the factors shown relating to the 'intercept', the project NPV and the discount rate and a degree of confidence surrounding the factor relating to the IRR.

A number of features of the equation are otherwise apparent:

- Statistically speaking, each percentage increase in the discount rate suggests a reduction in a junior exploration company's EV by US$30.8m.
- Every US$1m added to a company's project's NPV will add, on average, US$0.04m to its EV.
- Every percentage point that is added to a company's project's IRR will add, on average, US$0.5m to its EV.
- Every point by which a country increases its Fraser Index score of Investment Attractiveness will increase the EVs of the explorers operating within its borders by US$0.09m.

Whatever else, this equation appears to support our earlier findings of a relatively weak effect on valuations from sovereign risk (as measured by the Fraser Index) and a larger one from project IRRs. Perhaps more important is the implication that a change in a project's discount rate on a company's valuation appears to be more significant than the effect of the consequent change in NPV for all but the very largest projects.

(2) The second group of companies all had projects with NPVs calculated on the basis of an 8% discount rate. Hence, the discount rate was rendered redundant as an independent variable. In this case, the formula generated by the multiple regression analysis for calculating a company's EV could, on average, be stated as follows:

EV = -60.1 + (1.0 × Fraser) + (0.6 × IRR) + (0.04 × NPV in millions) − (1.1 × study type)

Without going into the details unnecessarily, in respect of this equation, suffice it to say that there is a good level of confidence surrounding the factors shown relating to the project NPV and a degree of confidence surrounding the factors relating to IRR and the Fraser Institute.

A number of features of the analysis are nevertheless otherwise apparent:

- The similarity of the magnitudes of the factors relating to IRR and NPV for both equations is striking.
- Every US$1m added to a company's project's NPV will add, on average, US$0.04m to its EV.
- Every percentage point that is added to a company's project's IRR will, on average, add US$0.6m to its EV.

- Every point by which a country increases its Fraser Index score of Investment Attractiveness will increase the EVs of the explorers operating within its borders by US$1.0m (cf US$0.09m in equation 1).

If these equations are then applied to notional 'average' companies, the equations predict EVs that are within 2.5% of those expected via our earlier EV/NPV analyses.

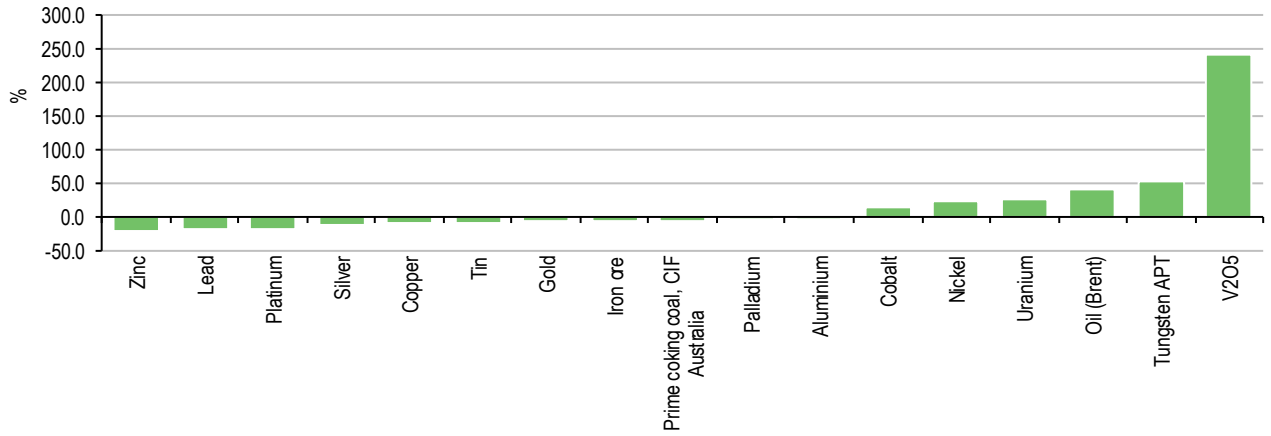
Readers are invited to come to their own conclusions regarding the veracity and accuracy of the equation within the context of this result. In Edison's opinion however, it seems (perhaps surprisingly) accurate.

Differentiated in-situ value analysis

In past publications, as well as average values for total resources, we have 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.

In this case (and in contrast to 2017), the 2018 analysis of the value of in-situ resources has been performed in an environment in which metals' prices have been generally falling. On average, over the course of the intervening 12 months, the prices of 11 commodities have fallen, while the prices of only six have risen – albeit the extent of the rises has been much larger than the extent of the falls, such that a simple average across all 17 suggests a rise, on average, of 16.8%. In broad terms, since our last in-situ analysis report, there has been one exceptional performer (vanadium), four very strong performers (tungsten, oil, uranium and nickel), followed by one solid performer (cobalt) and 11 fallers.

Exhibit 17: Price performance of major metals and minerals, August 2017 to August 2018 (%)



Source: Thomson Reuters Datastream, Edison Investment Research

In the individual sections below, the changes in in-situ values over the past year are interpreted within the context of these moves in commodity prices.

Gold

In general, valuations for gold resources eased slightly during the 2017–18 period, reflecting weakness in the gold market itself and, in particular, its decline from US$1,304/oz at the end of May 2018 to US$1,251/oz by the end of June. In common with recent practice, this report calculates the values of in-situ gold ounces differentiated with respect to the market in which they are listed (London, Canada and Australia), as well as by JORC category. Apart from the general easing in valuations overall, the other feature of the analysis is the increasing alignment of valuations across all three markets, with the highest rated market (Australia) recording the greatest decline in percentage terms, while the lowest rated market (London) recorded the smallest decline.

Exhibit 18: Global average value of in-situ explorers' gold resources, by listing, US$/oz

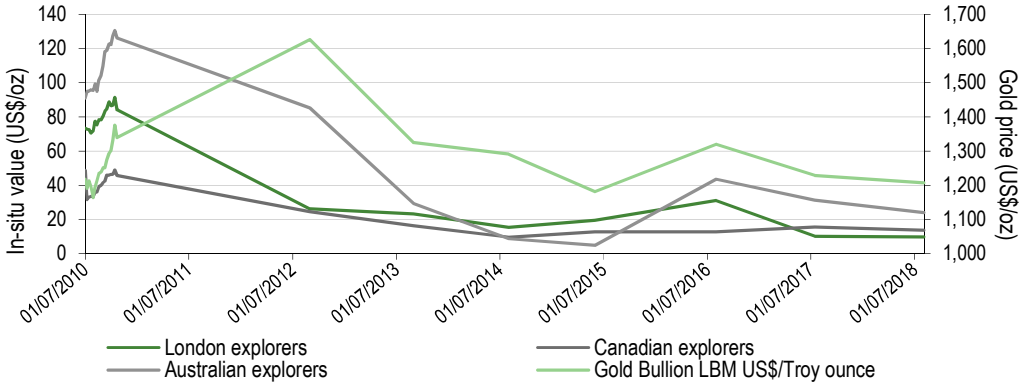
	July 2018				July 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
London market	61.19	8.68	7.87	9.88	17.88	10.27	7.33	10.34	86.74	28.39	10.51	31.17
Canadian market	29.12	13.82	7.87	13.83	47.49	6.92	11.64	15.68	87.52	(8.46)	6.00	12.81
Australian market	62.88	24.84	7.87	24.08	98.57	36.58	7.33	31.27	226.06	15.15	5.51	43.47
Arithmetic mean	**51.06**	**15.78**	**7.87**	**15.93**	**54.65**	**17.92**	**8.77**	**19.10**	**133.44**	**11.69**	**7.34**	**29.15**
Geometric mean	**32.78**	**12.33**	**11.07**	**14.95**	**43.70**	**12.89**	**11.00**	**17.54**	**35.66**	**15.65**	**7.61**	**16.84**

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

With more companies in the sector than London and Australia combined, Canada once again accounted for the majority (84.8% vs 81.5% in November 2017) of ounces analysed. While this means that Canadian valuations are therefore relatively over-represented in the calculation of the global geometric mean (see Exhibit 18, above), this was compensated for by the fact that it was able to provide credible sample sizes for companies with inferred resources only, which the London and Australian markets were not – hence the values for inferred ounces listed in London and Australia are assumed to be those calculated for the Canadian market, rather than being calculated independently, as in previous years.

Once again, there is a close convergence of the geometric and arithmetic means for the global market, conferring a level of confidence in both the valuation of total ounces and the sample size used to calculate the valuation. Recent trends in the valuation of resources in each market are shown in the exhibit below in conjunction with the gold price over the same period of time:

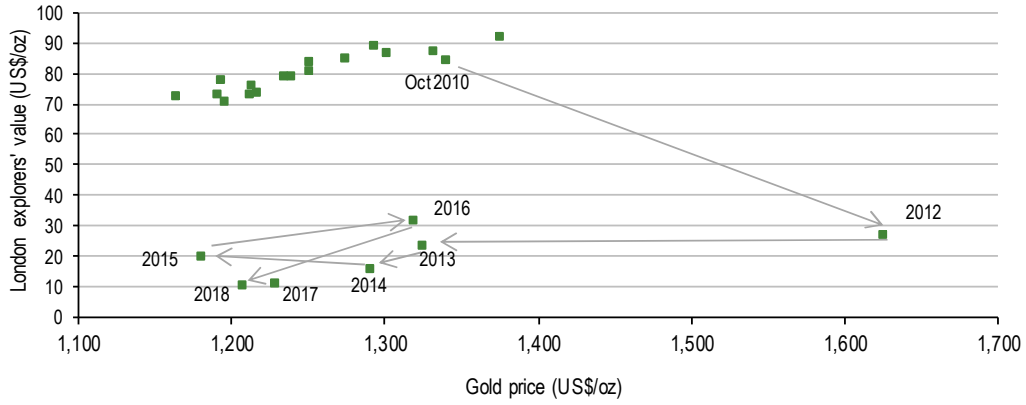
Exhibit 19: Gold resources valuations vs gold price (US$/oz), by market, 2010–18



Source: Edison Investment Research

Of note, within this context, is the fact that on at least two occasions, the valuation of resources has pre-empted moves in the gold price, in the period between October 2010 and 2012 (when lower resource valuations pre-empted a lower gold price after 2012) and between 2014 and 2015 (when higher resource valuations pre-empted a recovery, albeit temporary, in the gold price). For London-listed companies, this pre-emption may be demonstrated by the negative gradients of the 'time' lines in the following Exhibit:

Exhibit 20: London-listed gold resources valuations vs gold price (US$/oz), 2010–18

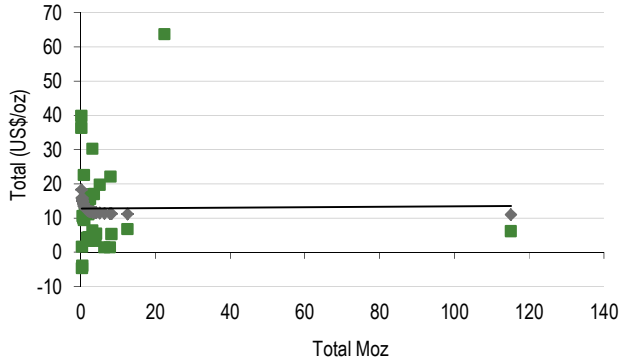


Source: Edison Investment Research

The other main feature of the analysis relates to the markets' discounting of the ultimate size of a particular resource:

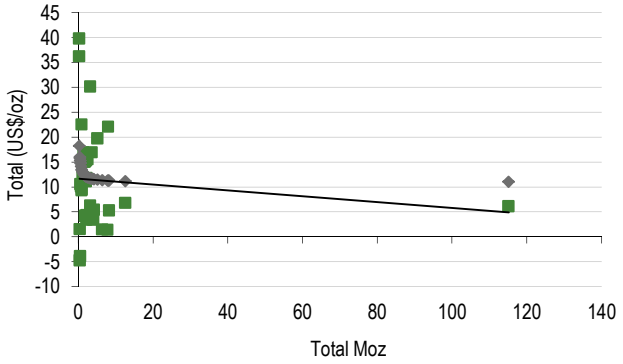
- Valuations overall remain consistent with bear market conditions.
- There is a logical progression in the values of inferred, indicated and measured ounces in all three markets in June 2018.
- In the case of the London market, there is statistically significant evidence at the 5% level, for a directional hypothesis, that the market does discount for future blue-sky discoveries – ie the market is prepared to ascribe higher valuations to smaller resources in the expectation (presumably) that they will increase in size over time. This apparent discounting was recognised for the first time for the London market only in this series of analyses in 2017. Note: one would probably assert a directional hypothesis between resource valuations and the gold price, all other things being equal; over time, however, clearly both the costs of discovery and costs of ultimate exploitation change and so this assertion is something of a matter of opinion – especially over longer time frames. Within this context, readers should note that, while the correlation between size and valuation is statistically significant at the 5% level for a directional hypothesis, given the sample size used to calculate the correlation coefficient, it is not statistically significant at the 5% level for a non-directional hypothesis.
- As in the case of the London market, there is also statistically significant evidence at the 5% level, for a directional hypothesis, that the Canadian market similarly discounts for future blue-sky discoveries, with the exception of a single data point, which represents a company with one of Canada's largest attributable resources, but also one of its highest resource ratings. Including this company in the analysis, however, renders the (inverse) correlation not statistically significant. Both analyses are provided in the exhibit below and readers are invited to choose whether they regard the data from this single company to be anomalous or not (note: in our opinion, there is no reason to consider that this company is anomalous within the context of the analysis, other than the fact that it was about to announce a disposal shortly after the analysis was conducted).

Exhibit 21: Graph of resource size (Moz) vs resource multiple (US$/oz) for Canada-listed explorers, 2018, including statistical outlier



Source: Edison Investment Research

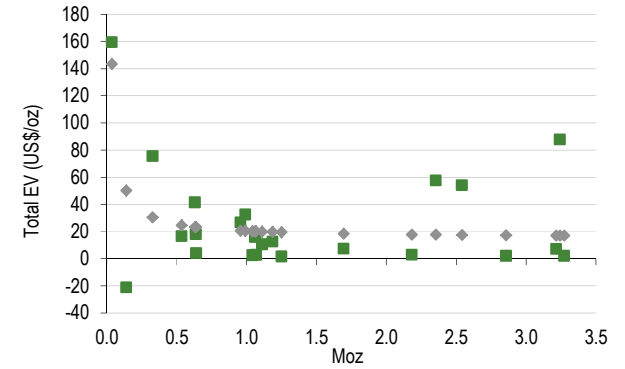
Exhibit 22: Graph of resource size (Moz) vs resource multiple (US$/oz) for Canada-listed explorers, 2018, excluding statistical outlier



Source: Edison Investment Research

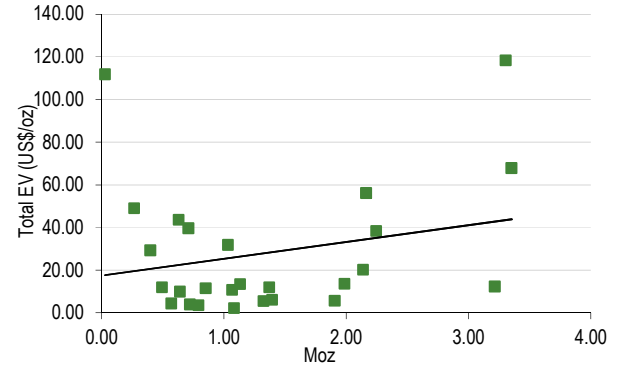
- There is (very strong) statistically significant evidence at the 5% level, for any hypothesis, that the Australian market similarly discounts for future blue-sky discoveries. This is in contrast to the result observed in November 2017, which suggested that the Australian market afforded premium valuations to larger resources (albeit the relationship was not statistically significant at the time).

Exhibit 23: Graph of resource size (Moz) vs resource multiple (US$/oz) for ASX-listed gold explorers, 2018



Source: Edison Investment Research

Exhibit 24: Graph of resource size (Moz) vs resource multiple (US$/oz) for ASX-listed gold explorers, 2017

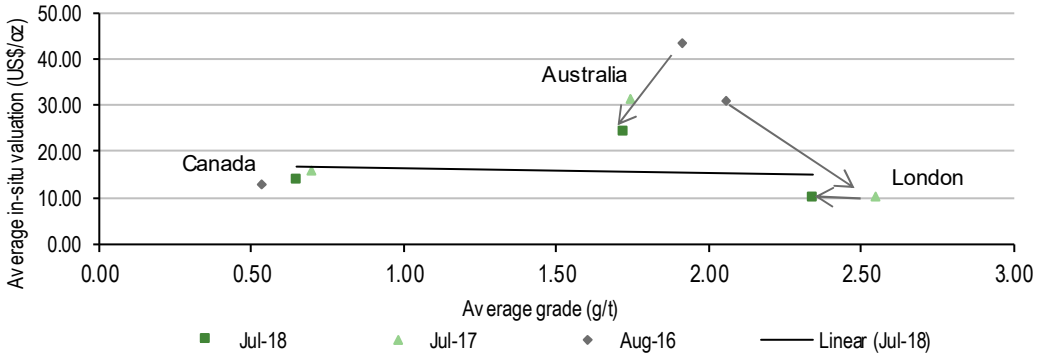


Source: Edison Investment Research

The implication of this observation across all three markets for the first time 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).

Notwithstanding our earlier observation that the highest rated market (Australia) had recorded the greatest decline in the valuation of its resources in percentage terms, this may be partly explained in terms of the continued decline in the weighted average grade of those resources, from 1.74g/t in November 2017 to 1.72g/t in June 2018, as depicted in the exhibit below:

Exhibit 25: Average in-situ valuation (US$/oz) vs average grade (g/t), by market



Source: Edison Investment Research

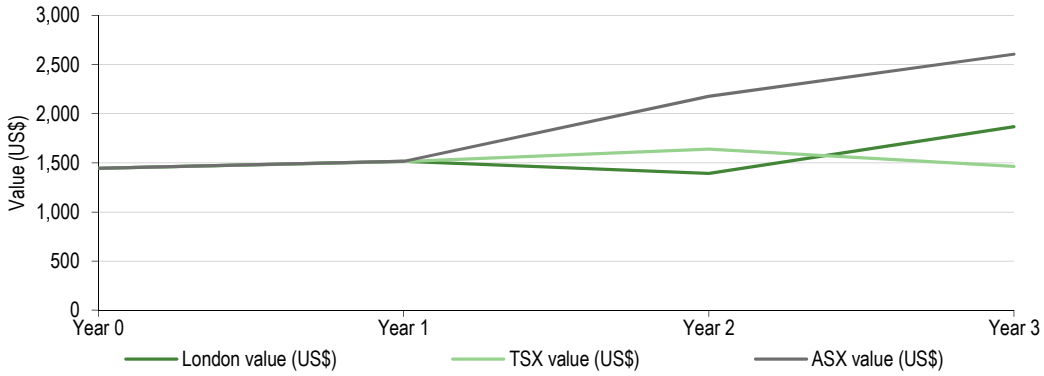
However, despite the continuing bear market valuations of in-situ ounces there nevertheless exists the possibility of a positive return for investors on exploration dollars in all three years (albeit to differing extents).

Financial returns on the gold exploration dollar

In the publication Gold: Valuation benchmarks are obsolete, we, 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 51.1:48.9, inferred:indicated, respectively, while companies with measured, indicated and inferred resources have them in the proportion 19.6:43.8:36.5, 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 19.6:43.8:36.5 would therefore be US$1,443 in aggregate. At the unit values shown in Exhibit 18, these resources would have a value of US$1,867 in London (vs US$1,112 in November 2017), US$2,608 in Australia (vs US$4,219) and US$1,462 in Canada (vs US$1,658), representing returns of 29.4% in London (vs -26.6% previously), +80.7% in Australia (vs +178.3% previously) and +1.3% in Canada (vs +9.4% previously), with an evolution over time as follows:

Exhibit 26: Average gold exploration value evolution over time (US$)



Source: Edison Investment Research

The global average return is 10.0% (vs 24.4% previously).

Note that, in Year 0, the company has cash of US$1,443; in Year 1, it has a resource of 100 inferred oz and cash of US$727; in Year 2, it has a resource of 51.1 inferred oz and 48.9 indicated oz and cash of US$564; and in Year 3, it has a resource of 36.5 inferred oz, 43.8 indicated oz and 19.6

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 27: Average gold resource values, by category, selected markets (%)

Resource category	London	Canada	Australia
Measured	64	39	47
Indicated	20	41	42
Inferred	15	20	11
Total	**100**	**100**	**100**

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

Gold multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots the sample companies' EVs against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. The formulae for each of these best-fit lines (in millions), for each of the three markets included in the above analysis are as follows:

London: EV = 1.9 + (14.02 × inferred oz) + (2.66 × indicated oz) + (17.77 × measured oz)

TSX: EV = 2.2 - (45.66 × inferred oz) + (71.58 × indicated oz) + (0.28 × measured oz)

ASX: EV = -13.5 - (7.08 × inferred oz) + (91.75 × indicated oz) - (48.95 × measured oz)

With the notable proviso that the above analysis provides a constant (the first argument in each of the equations), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. In general, however, they are not. Moreover, the statistical analysis associated with the multiple regression analysis suggests that the empirical results for the above factors should be taken with a pinch of salt. In general, values for t-stats are low and values for P-values are high (for greater confidence in the results, the reverse would be true). However, there are very notable exceptions:

- For the London market, there is a high level of confidence that the factor applied to inferred ounces lies between US$5.78–22.26/oz. This corroborates, to some extent, our decision to apply the same value to inferred ounces in the London market as that observed in the Canadian market (ie US$7.87/oz) in our in-situ analysis, above. At the same time, the positive sign associated with each factor in the London equation supports a supposition that adding resources of any type is value adding in the London market. However, the fact that the factor applied to inferred resources is greater than that for indicated resources implies that upgrading from the former to the latter is probably value destructive (which corroborates our findings in relation to Financial returns on the gold exploration dollar, above, and demonstrated in Exhibit 26, in particular). Finally, the fact that the largest factor is associated with the measured category of resources suggests that this is the most value adding of the three categories of resources to which to add (or upgrade) and tacitly supports the fact that we calculated a relatively high value for measured resources listed in the London market (see Exhibit 18).
- For the Canadian market, there is a high level of confidence that the factor applied to indicated ounces lies between US$61.56–81.60/oz. While this is materially larger than the value calculated in our in-situ analysis, above (namely US$13.82/oz), it nevertheless supports that broad conclusion in the section related to Financial returns on the gold exploration dollar, above, that it is by adding to, and upgrading to, the indicated category of resources that the most value is to be added to stock market valuations in the Canadian market.
- Similarly, in the Australian market, there is a high level of confidence that the factor applied to indicated ounces lies between US$48.08–135.41/oz. While this is significantly larger than the

value calculated in our in-situ analysis, above (namely US$24.84/oz), it nevertheless (again) supports the contention that adding to, and upgrading to, the indicated category of resources in the Australian market is materially value adding (as shown in Exhibit 26, above).

Uranium

In sharp contrast to recent years, uranium was one of the best performing metals & minerals over the course of the 12 months since our last analysis, rising 23.7%, and catalysing a 44.8% recovery in the average value of resources:

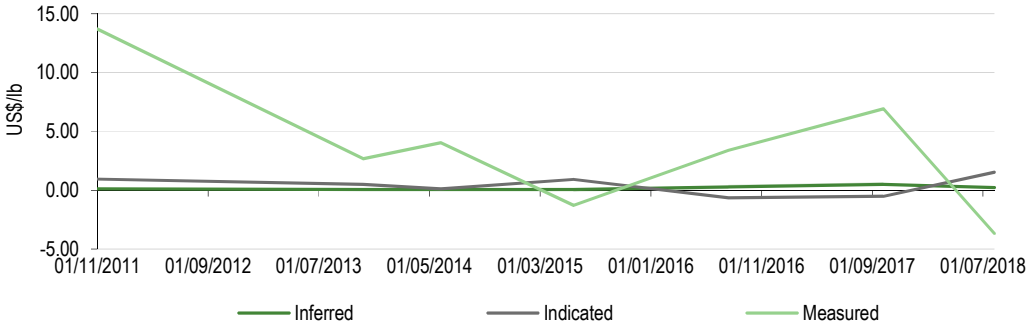
Exhibit 28: Global average value of in-situ explorers' uranium resources (US$/lb)

	July 2018				July 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ U_3O_8 value	(3.67)	1.52	0.22	0.46	6.93	(0.53)	0.50	0.32	3.40	(0.64)	0.28	0.15
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.

The fact that the implied value of measured resources is negative, as well as being at a discount to the implied value of indicated resources, is, at first glance, nonsensical. However, this yo-yoing of the values of measured relative to indicated resources has been a persistent feature of the market for at least the past three years.

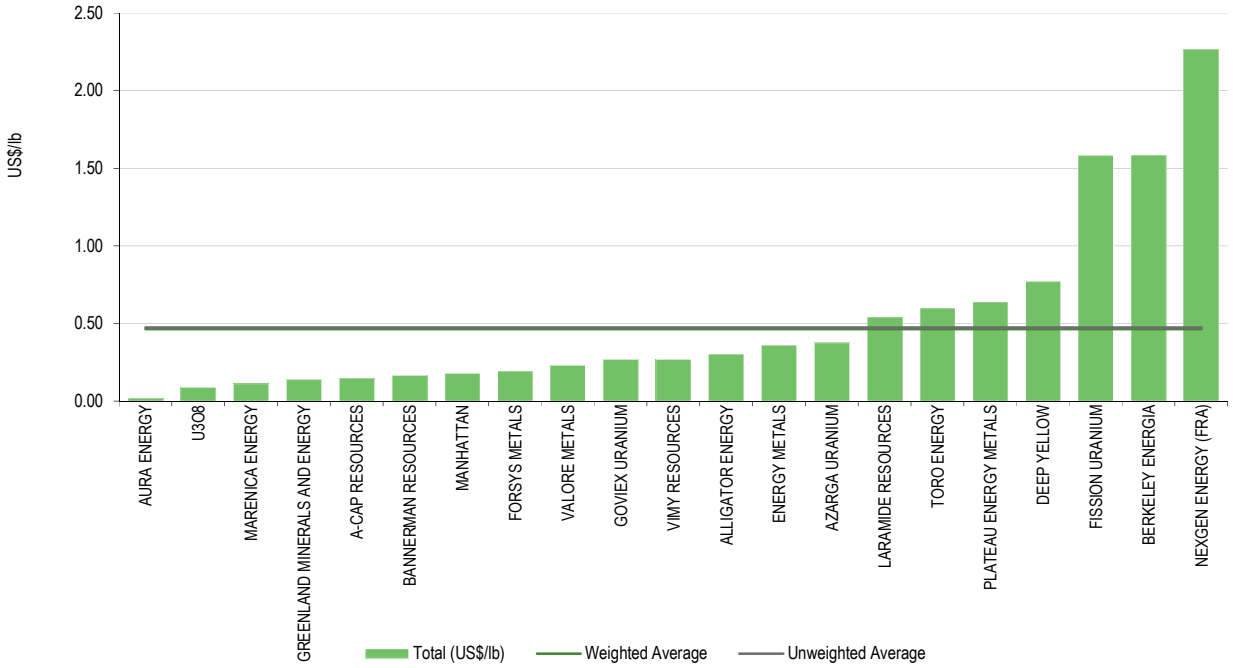
Exhibit 29: Value of explorers' in-situ uranium resources, by category, 2011–18 (US$/lb)



Source: Edison Investment Research

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 resource category:

Exhibit 30: Implied value of total uranium lbs in-situ

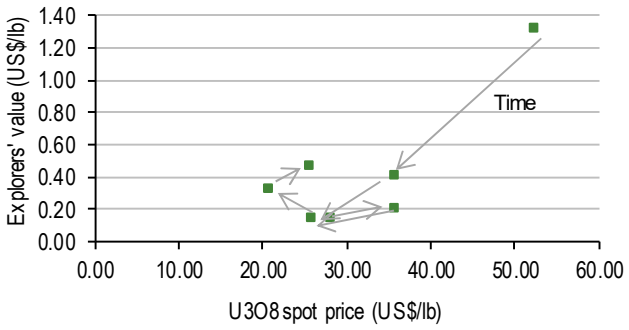


Source: Edison Investment Research

Considered thus, six companies (the three at the top of the distribution and the three at the bottom end) have in-situ values for their total resources more than one standard deviation away from the mean (weighted). Two of these (Nexgen and Fission) may be considered as persistent special cases on account of their locations on the western edge of the Athabasca Basin (widely viewed as a premium location).

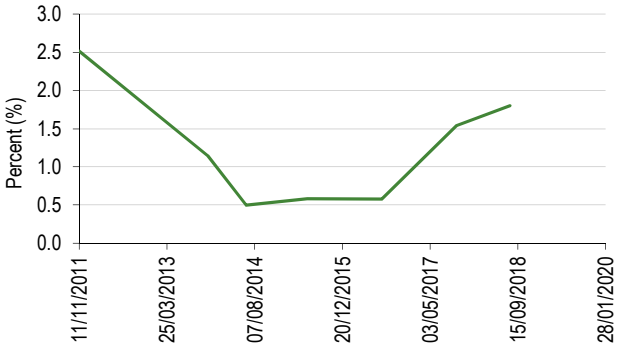
Nevertheless, considered within the historical context, the average in-situ value of uranium pounds has demonstrated a continued recovery in both absolute and relative terms. Note also that, once again, the equity markets appear to have pre-empted the commodity markets, as evidenced by the rise in the value of in-situ resources since their recent nadir in July 2016, ahead of the recovery in the price of uranium itself since December 2016.

Exhibit 31: In-situ value of total uranium resources vs spot price of uranium, 2011–18



Source: Edison Investment Research

Exhibit 32: In-situ value of total uranium resources as percent of the spot price of uranium, 2011–18

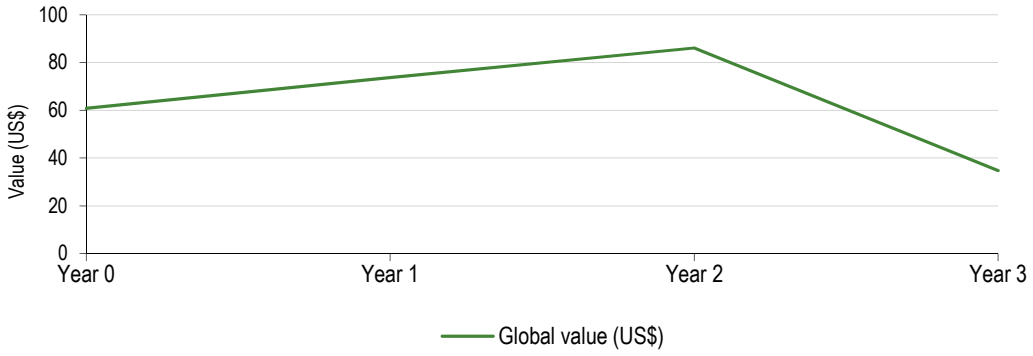


Source: Edison Investment Research

Companies with indicated and inferred ounces only have them in the proportion 73.6:26.4, inferred:indicated, respectively, while companies with measured, indicated and inferred resources have them in the proportion 11.6:44.5:44.0, respectively. On the basis of the unit cost estimates detailed in Exhibit 2 on page 5, the cost to drill up a typical, average deposit of 100lb, in the ratio

11.6:44.5:44.0 would therefore be US$60.78 in aggregate. Notwithstanding the rise in average values, therefore, returns on uranium spend nevertheless remain negative overall – eg -42.8% (cf -57.5% previously) for a company seeking to delineate a theoretical 100lb resource at the average percentage categorisations prevailing at the time of writing:

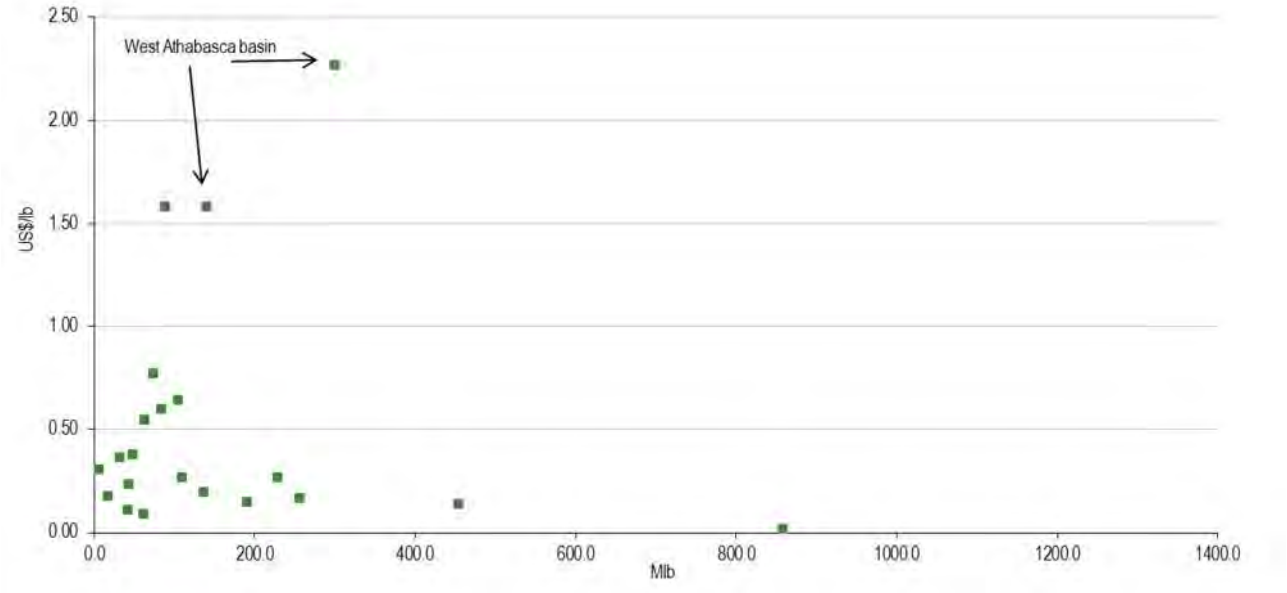
Exhibit 33: Value evolution of junior uranium explorer developing 100lb resource, 2018 (US$)



Source: Edison Investment Research

However, contrary to previous years, (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 and Mining overview: Unlocking the price to NPV discount, published in November 2017), there is no longer statistically significant evidence of the market continuing to discount future exploration success among uranium explorers.

Exhibit 34: Graph of resource size (Mlbs) vs resource multiple (US$/lb) for U_3O_8 explorers, July 2018



Source: Edison Investment Research

Uranium multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots the sample companies' EVs against their measured, indicated and inferred resources (effectively in four

dimensions) and then calculates the best-fit line between the points. In the case of the uranium sector, the formula for the best-fit line (in millions) derived via such an analysis is as follows:

EV = -31.5 + (0.07 × inferred lb) + (2.34 × indicated lb) − (3.11 × measured lb)

With the notable proviso that the above analysis provides a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. Allowing for the fact that the two approaches represent entirely different analyses, this can be seen to be broadly true. A summary of the statistical outputs of the multiple regression analysis is as follows:

Exhibit 35: Uranium explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	-31.5254518	41.04809	-0.76801	0.454401	-119.017	55.96649
Inferred	0.074697348	0.142328	0.524824	0.607376	-0.22867	0.378063
Indicated	2.341540391	0.570406	4.105039	0.000937	1.125748	3.557333
Measured	-3.115155551	1.522908	-2.04553	0.058756	-6.36116	0.130847

Source: Edison Investment Research

In this case, all of the results of our in-situ analysis, above, fall within ranges (lower 95% and upper 95%) implied by the multiple regression analysis. Moreover, there is a relatively high level of confidence attached to the coefficients relating to the indicated and measured categories of resources (as demonstrated by their relatively large t-stat outputs and their relatively small associated P-value). In this case therefore, the multiple regression analysis appears to both complement and corroborate our earlier, in-situ analysis – and particularly in the conclusion that by far the best way for uranium juniors to add value to their stock market valuations is by the upgrading of inferred resources into the indicated category, but emphatically not the upgrading of indicated resources into the measured category.

Finally, however, it is also worth noting that the 'intercept', although there is quite a large degree of uncertainty about its absolute level, is nevertheless the largest negative number of those calculated in this report and carries the implication that a uranium junior attempting to list with no resources would come to the market with a negative valuation of US$31.5m. For that reason, it probably suggests that uranium juniors are some of the most difficult companies to list in a sector that is already not wholly easy to sell to the market. Stated alternatively, if the 'intercept' implied by the multiple regression analysis is correct then, at the average value of in-situ uranium resources of US$0.46/lb, above, a junior would need to have a resource of at least 68.5Mlbs (on average and all other things being equal) in order to be ascribed any value (cash excepted) on the world's stock exchanges. Note that this observation/conclusion is probably also consistent with the earlier conclusion of the in-situ analysis that there is no longer statistically significant evidence of the market continuing to discount future exploration success among uranium explorers (ie the erstwhile pattern of small resources having relatively high values to reflect blue-sky exploration upside).

Silver

As among the gold juniors, the last 11 months among the silver juniors has generally been characterised by a continued easing of valuations in tandem with a slight easing of the silver price, from US$16.10/oz in July 2017, to US$15.84/oz at the time that this analysis was performed in June 2018.

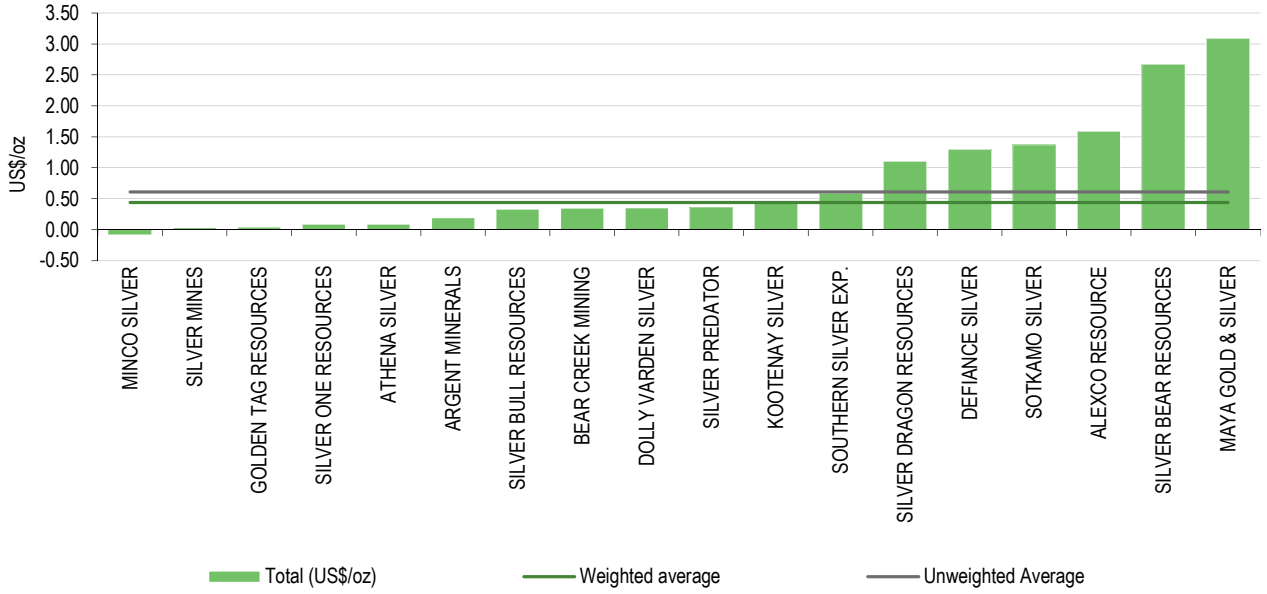
Exhibit 36: Global average in-situ value of explorers' silver resources (US$/oz)

	June 2018				July 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ silver value	(0.65)	0.25	1.29	0.44	0.45	0.18	1.28	0.56	(2.07)	1.16	0.13	0.59

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

A complicating factor in the analysis of the silver subsector is the fact that there is only one company with inferred resources only, which may be giving rise to an anomalously high inferred value, thereby depressing the value of indicated ounces, in particular. As with uranium, analysis of silver explorers suggests that the market could look on all ounces equally, rather than differentiating by resource category.

Exhibit 37: Implied value of total silver in-situ resources (US$/oz)

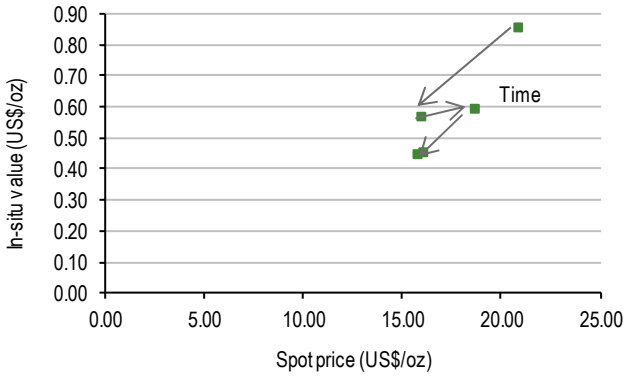


Source: Edison Investment Research

Anecdotally, however, imposing a value of US$0.35/oz for inferred resources (halfway between zero and the blended average value for total ounces for companies with indicated & inferred ounces only) implies a value for indicated resources of US$0.97/oz and a value for measured resources of minus US$1.32/oz. Significantly, in both instances, it can be seen that the value of measured resources is negative, thereby implying that value among junior silver exploration shares is carried by the indicated and inferred categories of resources, but not the higher confidence level category.

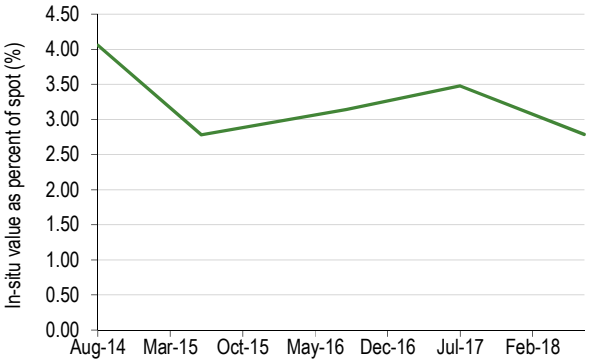
Nevertheless, the overall value of average silver ounces is approximately where it would be expected to be, given recent past experience (see Exhibit 38) and the level of the silver price although, in percentage terms, in-situ silver resources are close to their lowest level ever within the context of this analysis (Exhibits 39 and 142).

Exhibit 38: In-situ value of total silver resources vs spot price of silver, 2014–18



Source: Edison Investment Research

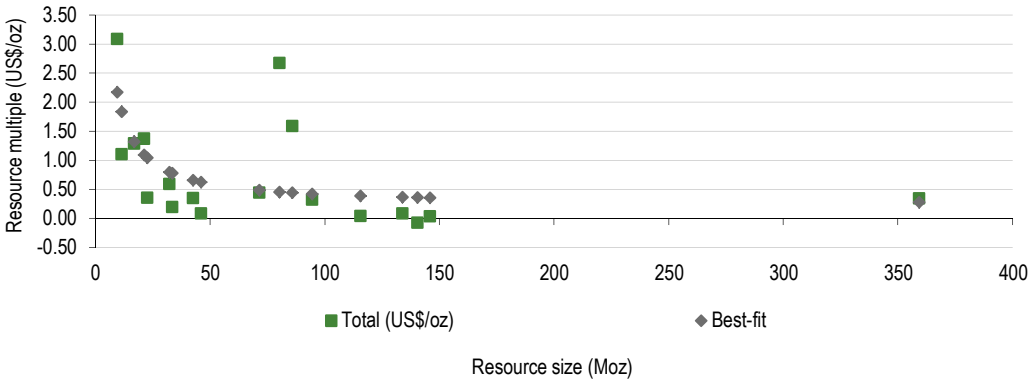
Exhibit 39: In-situ value of total silver resources as percentage of silver spot price, 2014–18



Source: Edison Investment Research

For the second year in succession, there is also statistically significant evidence that investors in silver explorers are prepared to afford value to companies for resources that have yet to be formally delineated:

Exhibit 40: Graph of resource size (Moz) vs resource multiple (US$/oz) for silver explorers, July 2018



Source: Edison Investment Research

Silver multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots the sample companies' EVs against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. In the case of the silver subsector, the formula for the best-fit line (in millions) derived via such an analysis is as follows:

EV = 46.7 − (0.76 × inferred oz) + (0.62 × indicated oz) − (0.84 × measured oz)

With the notable proviso that the above analysis includes a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. Anecdotally, this may be seen to be approximately true for the measured and indicated categories of resources, but not true for the inferred category. A summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above is as follows:

Exhibit 41: Silver explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	46.699102	22.08062	2.114936	0.052851	-0.65912	94.05732
Inferred	-0.7616132	0.603571	-1.26184	0.227623	-2.05615	0.532919
Indicated	0.6246703	0.347952	1.795276	0.09422	-0.12161	1.370953
Measured	-0.8362691	0.936252	-0.89321	0.386842	-2.84433	1.171792

Source: Edison Investment Research

In the case of the measured and indicated categories of resources, the values calculated in our in-situ analysis, above (see Exhibit 36) fall within the ranges (lower 95% and upper 95%) implied by the multiple regression analysis. In addition, there is also a relatively high level of confidence attached to the coefficients relating to the 'intercept' and the indicated category of resources (as demonstrated by their relatively large t-stat outputs and their relatively small associated P-value). In general, therefore, the multiple regression analysis appears to complement our in-situ analysis – albeit with the exception of the value of inferred resources, which had anyway been brought into question in the in-situ analysis by virtue of the fact that there was only one company in the sample with inferred resources only. Considered together, we can probably state reasonably confidently that the best way for silver explorers to add value to their stock market valuations is by adding to their indicated resources. It may (but only may) be possible to achieve the same result by adding to inferred resources as well, but under almost any circumstances it appears that adding to the measured category of resources is likely to be value destructive.

Within the context of the silver subsector, it is also worth noting that the 'intercept' is the largest positive number of those calculated in this report and carries the implication that a silver explorer listing with no resources could nevertheless be afforded an enterprise value of c US$46.7m – which is, to some extent, also consistent with our earlier observation that there is statistically significant evidence of the market discounting future exploration success among silver explorers (ie the pattern of small resources having relatively high values to reflect blue-sky exploration upside).

Iron ore

In common with the majority of metals and minerals analysed by Edison in 2018, the price of iron ore eased slightly during the period under review and was attended by an easing in the overall valuation of resources.

Exhibit 42: Global average in-situ value of explorers' iron ore resources (US$/t Fe)

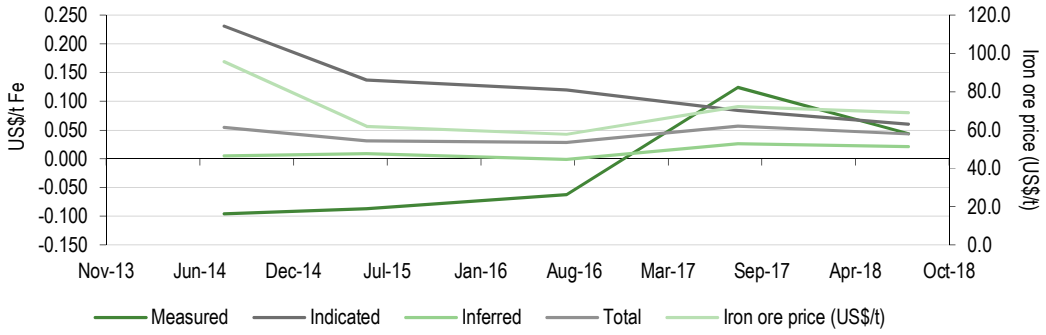
	August 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ iron ore value	0.044	0.060	0.021	0.043	0.125	0.084	0.026	0.057	(0.062)	0.120	(0.001)	0.028

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

As with the silver juniors, a complicating factor in the analysis of the iron subsector is the fact that there was only one company with inferred resources only – although, in this case, the valuation for inferred resources from this data point did not appear anomalous and could even have been assumed to be higher (albeit not, logically, exceeding US$0.036/t Fe – in which case the value of indicated resources would also have been US$0.036/t Fe and the value of measured US$0.082/t Fe).

As things stand however, accepting the valuations in Exhibit 42, above, measured resources have lost the premium valuation that they enjoyed relative to indicated and inferred resources last year. However, this has been a fairly persistent feature of the market in recent history:

Exhibit 43: In-situ value of total iron ore resources, by category, and iron ore spot price, 2014–18

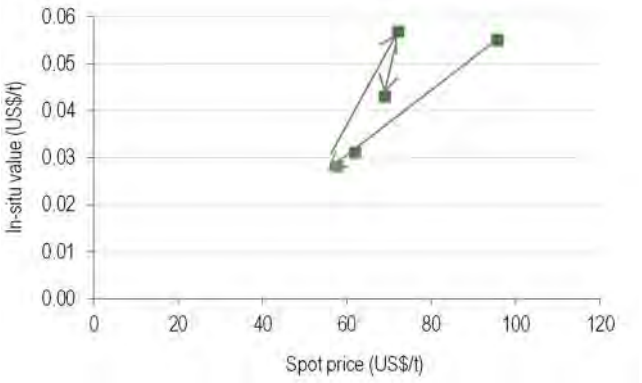


Source: Edison Investment Research

One notable feature of the above graph is that the values of indicated and inferred resources appear to approximately track changes in the price of iron ore itself, while the value of measured resources appears to reflect what might be regarded as the 'residual' valuation – ie what remains after the valuations of the lower two confidence categories have been taken into account.

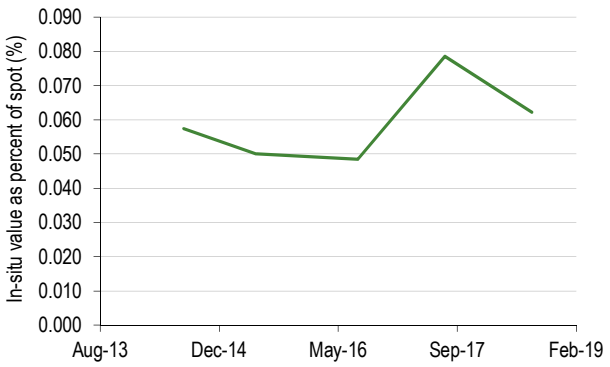
Overall, although the decline in in-situ valuations was greater than might otherwise have been expected, given the relatively modest decline in the spot price of iron ore itself, this may in fact simply represent a moderation from the position a year before, when in-situ values appeared to have increased more than expected, given the (albeit unexpected) increase in the iron ore price. As a percentage of the spot price of iron ore, the value of in-situ resources is at a relatively elevated level within the context of recent history. Nevertheless, that percentage remains an order of magnitude below that prevailing during the bull market of 2011/12 when, anecdotally, we estimate that in-situ values approximated 1.0% of spot values (see Exhibit 141).

Exhibit 44: In-situ value of total iron ore resources vs iron ore spot price, 2014–18



Source: Edison Investment Research

Exhibit 45: In-situ value of total iron ore resources as percent of iron ore spot price, 2014–18

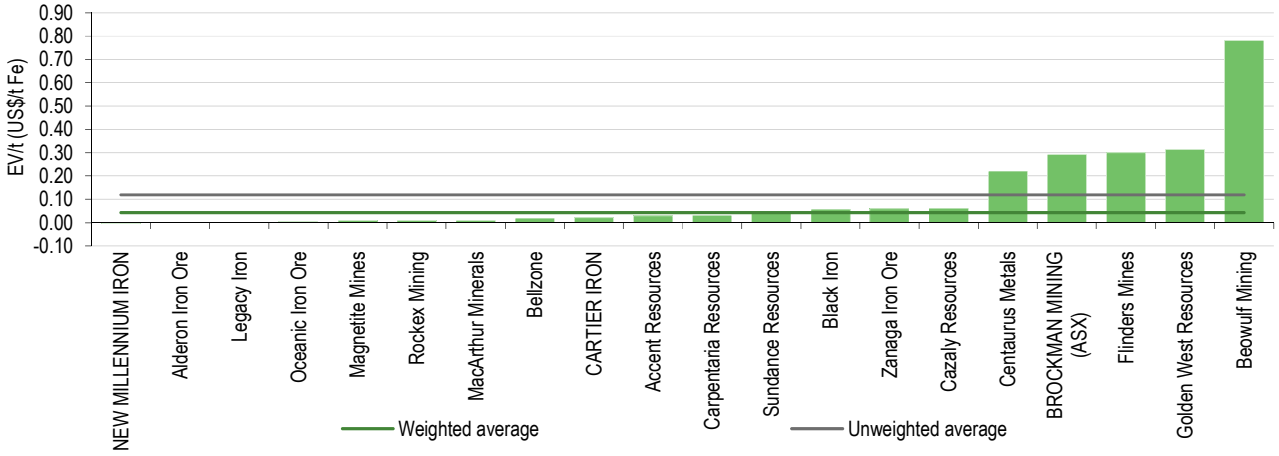


Source: Edison Investment Research

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, we estimate that in-situ values approximated 1.0% of spot values (see Exhibit 112).

While it is tempting to interpret the valuation of iron ore resources by equity markets as being in relation to total resources, rather than resources differentiated by category, there is perhaps some evidence that there are two distinct populations within the sample, representing those companies with a premium valuation and those companies with an ordinary valuation:

Exhibit 46: Implied value of total in-situ iron ore resources (US$ per tonne Fe)

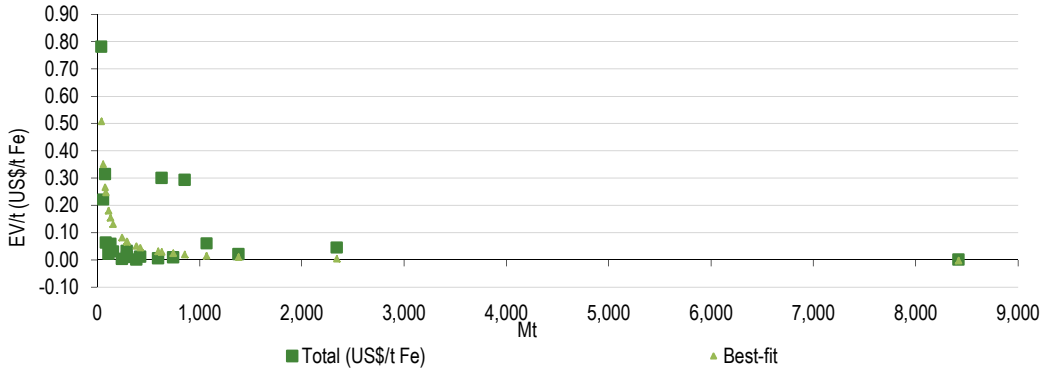


Source: Edison Investment Research

Within this context, readers should note that the implied valuations of the resources of the top four companies in the graph above (ie Brockman to Beowulf) lie more than one standard deviation above the weighted mean of the population.

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

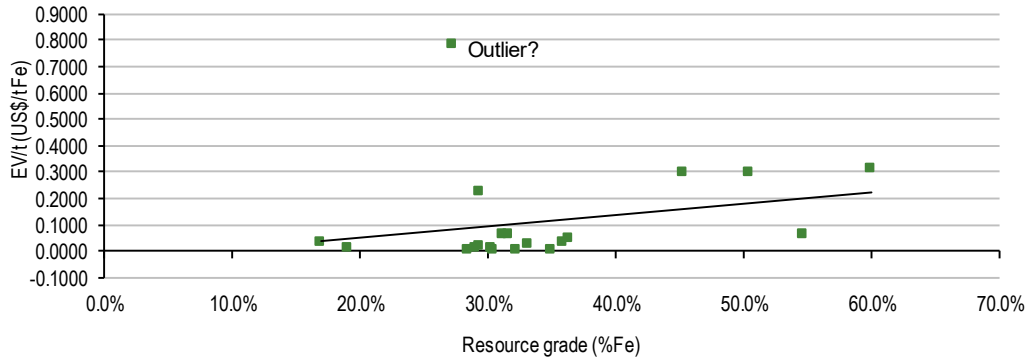
Exhibit 47: Graph of resource size (Mt Fe) vs resource multiple (US$/t Fe) for iron ore explorers, August 2018



Source: Edison Investment Research

There is also evidence that investors in the subsector value the existing grade of a deposit in addition to its blue-sky potential. While this is not, at first glance, statistically significant (with a Pearson product moment coefficient of 0.25 for the whole sample), it very definitely becomes so (with a Pearson product moment coefficient of 0.67) if the outlier (highlighted), is removed from the population:

Exhibit 48: Graph of resource grade (% Fe) vs resource multiple (US$/t Fe) for iron ore explorers, August 2018



Source: Edison Investment Research.

Iron ore multiple regression analysis

No multiple regression analysis was performed for iron ore juniors in 2018. We hope to add this in future years.

Platinum group metals (PGMs)

The analysis of the platinum sector is complicated by four factors:

- The fact that Wesizwe and Jubilee Platinum have entered production since the equivalent analysis in 2017, which leaves the population of platinum explorers analysed in this report numbering only three.
- There are no companies with inferred resources only.
- For the first time ever, there were no companies in the PGM subsector with assets in South Africa's Bushveld Igneous Complex (the resources of which have previously dominated this section of the report), with the remaining two South African Bushveld companies (Wesizwe and Jubilee) either being deep into development or having entered production since the date of our last analysis.
- Despite their names, many of the assets owned by the companies analysed contain material amounts of co-products

With these caveats, our best estimate of the differentiated values of measured, indicated and inferred resources in the PGM subsector, in platinum equivalent terms (PtE), is as follows:

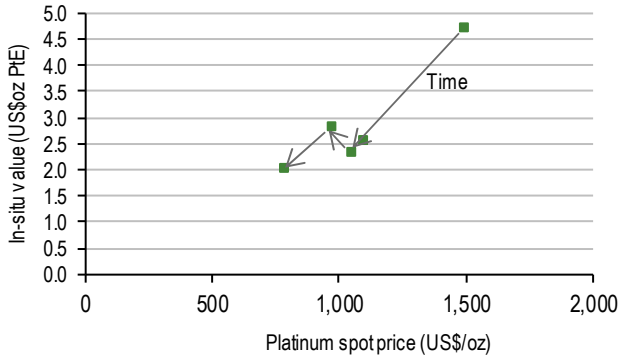
Exhibit 49: Global average in-situ value of explorers' PGM resources (US$/oz PtE)

	August 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ PGM value (US$/oz PtE)	(25.81)	7.77	3.61	2.00	(76.55)	29.44	2.38	2.78	(9.24)	2.98	2.98	2.31
Cost of discovery (US$/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.

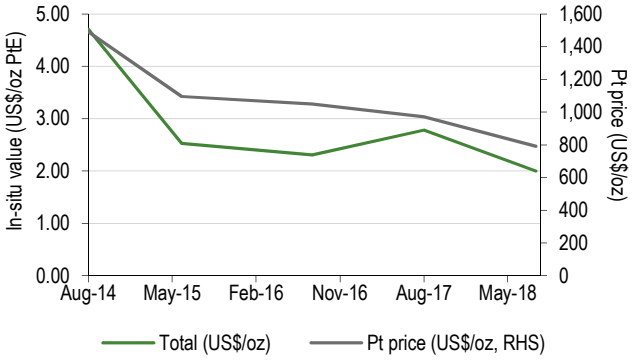
In general, the period under review was characterised by a decline in both platinum and palladium prices and a consequent decline in in-situ resource valuations from a position in 2017, which appeared to imply that equity markets were discounting a future recovery in PGM prices:

Exhibit 50: Graph of average PGM in-situ value (US$/oz PtE) vs Pt spot price (US$/oz), 2014–18



Source: Edison Investment Research

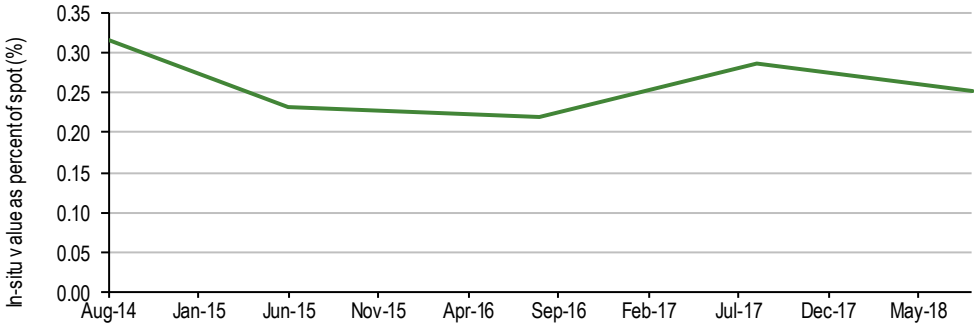
Exhibit 51: Graph of average PGM in-situ value (US$/oz PtE) vs Pt spot price (US$/oz), 2014–18



Source: Edison Investment Research

As a result, the value of in-situ resources as a percentage of the spot price of platinum has remained relatively constant within a relatively narrow recent range:

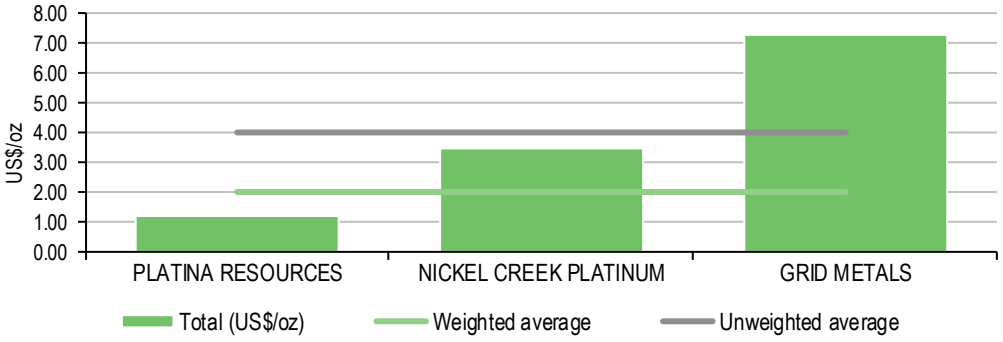
Exhibit 52: Average PGM in-situ value as a percentage of the Pt spot price, 2014–18



Source: Edison Investment Research

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

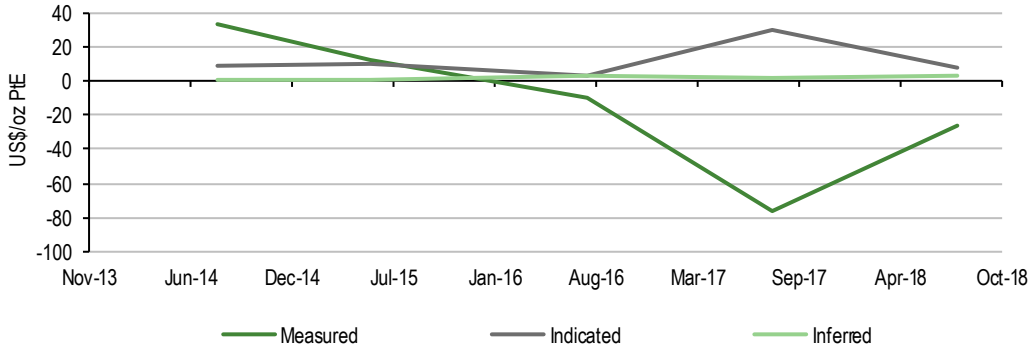
Exhibit 53: Implied in-situ value of total PGM resources (US$/oz PtE)



Source: Edison Investment Research

Notwithstanding the caveats noted above, however, the implied valuations of the different categories of resources appear to be consistent with recent historical experience, with the discount in the value of measured resources even appearing to narrow relative to the value of indicated resources. This is something of a surprise given the absence of Bushveld assets within the population for the first time – meaning, among other things, that the differentiated values of the resource categories should not be compared directly to the cost of discovery noted in Exhibit 2, since these explicitly relate to deep-level, South African, narrow reef structures. If instead, they are compared to global average gold costs of discovery (also Exhibit 2), then it becomes very difficult to see how junior platinum explorers can increase their stock market valuations via resource expansion and/or upgrades unless it can be achieved at an unusually low cost. Stated alternatively, companies in the PGM sub-sector appear to suffer from the low valuation benchmarks created by their peers in the Bushveld (relative to platinum's price and crustal abundance – see Exhibits 139 and 140) but fail to benefit from the geological implications (including relatively low costs of discovery) of operating there.

Exhibit 54: In-situ value of PGM resources (US$/oz PtE), by category, 2014–18

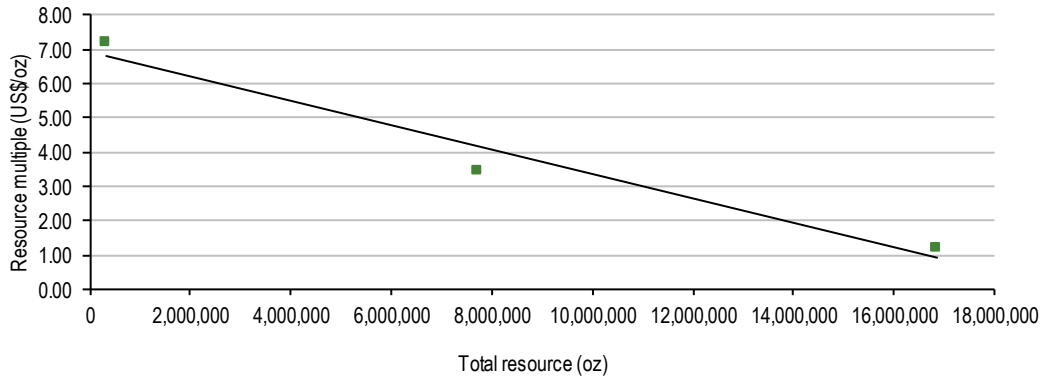


Source: Edison Investment Research

As a result of the absence of South African Bushveld assets within the sample, with which to compare assumed South African costs of discovery, we have foregone our usual analysis of the evolution of value within a PGM explorer as it first delineates and then upgrades its resources.

Finally, although there is anecdotal visual evidence of the equity markets discounting future exploration success, given the number of data points in the population, this could not be said to be statistically significant), although, in the case of PGMs, it may be that the relationship is linear (as in 2017), rather than the more commonly observed inverted relationship. However, the consolation of this is that it may then be possible for managements to add value to junior PGM exploration companies by increasing their resources if conducted at an appropriate cost.

Exhibit 55: Resource size (oz) vs resource multiple (US$/oz PtE) for PGM explorers (2018)



Source: Edison Investment Research

PGM multiple regression analysis

No multiple regression analysis was performed for PGM juniors in 2018 – not least owing to the paucity of available data. Nevertheless, we hope to add this in future years.

Nickel

Although it retraced, in the period from June 2018 to August 2018, almost half of the gain that it had made in the period from August 2017 to June 2018, nickel was still one of the standout performers among its peers in the period under review (see Exhibit 17 on page 17), at least partly as the markets have begun to digest the implications of the electrification of the world's vehicle fleet on likely future nickel demand.

In common with previous years, our nickel analysis has been subdivided into separate analyses for sulphide and laterite deposits to reflect the different natures and processing requirements of those ore bodies.

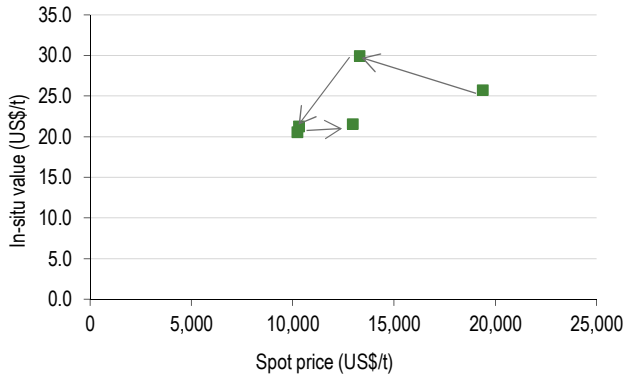
Exhibit 56: Global average in-situ value of explorers' nickel resources (US$/t)

	August 2018				September 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ nickel value (US$/t)	144.18	16.68	4.51	19.75	95.37	16.51	4.46	16.44	106.62	22.11	5.87	19.43
Ditto (sulphide deposits)	131.23	22.53	5.41	21.52	95.50	24.29	5.83	20.51	92.24	27.50	6.44	21.20
Ditto (laterite deposits)	145.54	10.80	3.31	16.21	45.55	8.63	2.65	8.15	79.02	14.38	4.67	11.27

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

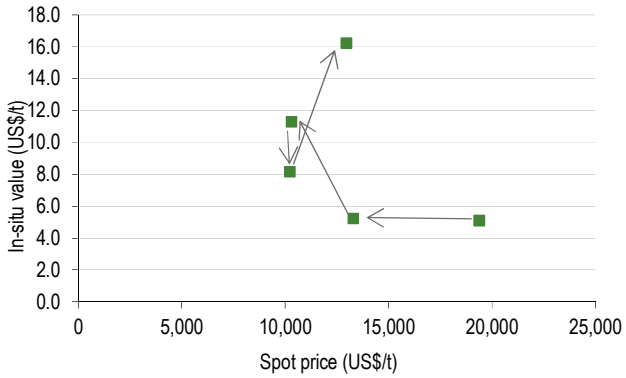
Of immediate note is the continued premium valuation accorded to sulphide resources compared to laterite ones (as expected). Within that context, however, it is also notable that the valuation of sulphide resources (while at a premium to laterite resources) is below that expected given recent historical experience, while the valuation of laterite resources is above that expected – such that the premium for sulphide resources is the smallest it has ever been over the course of the five years under review.

Exhibit 57: In-situ value of nickel sulphide resources vs spot price of nickel, 2014–18



Source: Edison Investment Research

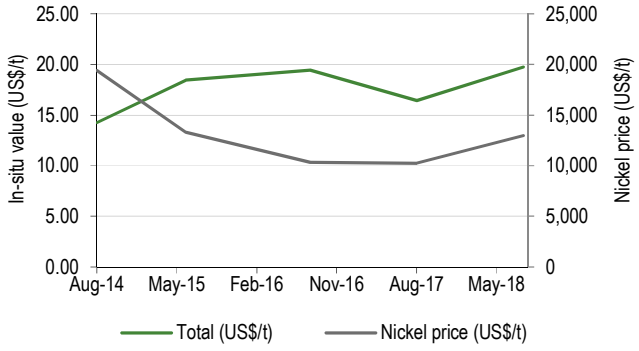
Exhibit 58: In-situ value of nickel laterite resources vs spot price of nickel, 2014–18



Source: Edison Investment Research

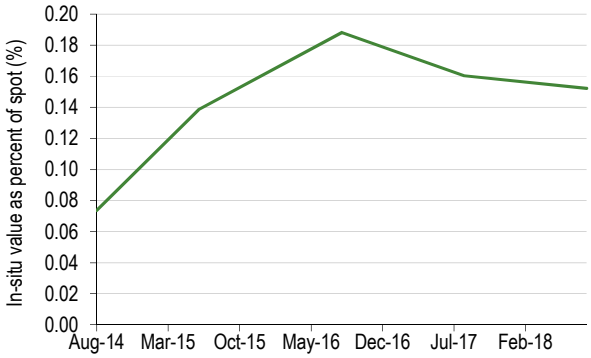
Nevertheless, looked at across the sector as a whole, it can be seen that changes in in-situ values among nickel juniors have broadly tracked moves in the nickel metal market, after a period of time in which the two appeared to be moving in counter phase, such that the average value of in-situ resources as a percentage of the price of nickel has remained approximately stable over the course of the past 11 months:

Exhibit 59: In-situ value of nickel resources and spot price of nickel, 2014–18 (US$/t)



Source: Edison Investment Research. Note: Sulphide and laterite resources combined.

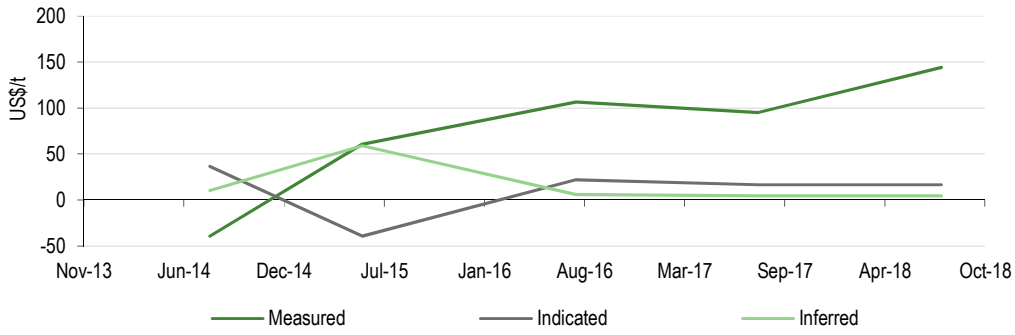
Exhibit 60: In-situ value of nickel resources as a percentage of the spot price of nickel, 2014–18 (%)



Source: Edison Investment Research. Note: Sulphide and laterite resources combined.

As in previous years, the overall size of the nickel sample of companies was small. In addition, there were no companies with inferred resources only, with the result that the differentiated analysis of in-situ values required an assumption that the value of inferred resources was halfway between zero and the blended average value of resources for companies with indicated and inferred resources only. Within this context, however, it is nevertheless very apparent that measured resources have extended the value premium established over the other two categories of resources since June 2015:

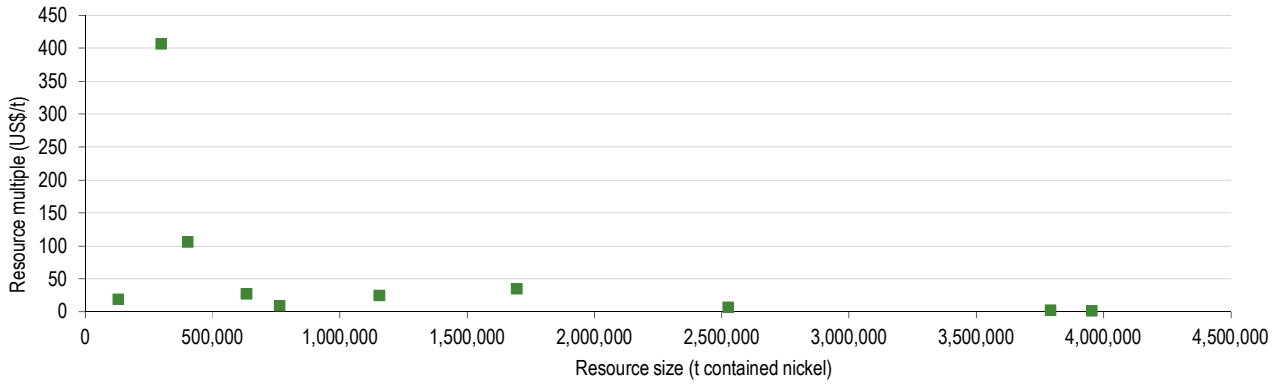
Exhibit 61: In-situ value of nickel resources, by category, 2014–18 (US$/t Ni)



Source: Edison Investment Research. Note: Total nickel sector with sulphide and laterite resources combined.

Finally, while visually quite compelling, investors should note that, for the number of data points in the sample, in mathematical terms the correlation between resource multiple and (invested) resource size is not statistically significant at the 5% level and therefore should be regarded as nothing more than a matter of conjecture, at best, at the current time.

Exhibit 62: Resource size (t Ni) vs resource multiple (US$/t Ni) for nickel explorers



Source: Edison Investment Research

Nickel multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots EVs of the companies in each subsector against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. In the case of the nickel subsector, the formula for the best-fit line (in millions) derived via such an analysis is as follows:

EV = 41.1 - (17.38 × inferred tonnes) - (3.19 × indicated tonnes) + (40.23 × measured tonnes)

With the notable proviso that the above analysis includes a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. In general, this may be regarded as anecdotally true in terms of direction, if not in terms of magnitude. That is to say, in both the in-situ analysis and the multiple regression analysis, it is apparent that the value attributable to a nickel junior from its resources is derived, to all intents and purposes, exclusively from the resources that it has delineated in the measured category only and not from those in either the indicated or inferred categories. A summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above is as follows:

Exhibit 63: Nickel explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	41.13037496	19.92102597	2.064671519	0.084508	-7.614619586	89.8753695
Inferred	-17.37792058	17.64023628	-0.985129694	0.362603	-60.54202379	25.78618264
Indicated	-3.189839661	30.67323952	-0.103994221	0.920563	-78.24455295	71.86487362
Measured	40.23399206	92.32420681	0.435790281	0.678231	-185.6752037	266.1431879

Source: Edison Investment Research

While the values calculated for measured, indicated and inferred resources in our in-situ analysis above (see Exhibit 56) fall within the ranges (lower 95% and upper 95%) implied by the multiple regression analysis (see Exhibit 63, above), it is apparent that these ranges are very wide and that, consequently, there is relatively low confidence in the figures themselves (as evidenced by their relatively small t-stat values and relatively high P-values). However, this does not negate the observation that the value attributable to a nickel junior from its resources is probably derived, to all intents and purposes, from that portion of its resources in the measured category (especially when taken in conjunction with the results of the in-situ analysis, which have fairly consistently demonstrated this pattern over a period of more than three years). The single exception to this observation about confidence relates to the constant in the equation (as demonstrated by its

relatively large t-stat outputs and its relatively small associated P-value). As with the silver subsector, this is one of the largest positive constants of those calculated in this report (and, in this case, associated with a relatively high degree of confidence) and carries with it the implication that a nickel explorer listing with no resources could nevertheless attract an enterprise value of c US$41.1m.

Potash

As with our nickel analysis, our potash analysis has been subdivided 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 these products and ore bodies.

Exhibit 64: Global average in-situ value of explorers' potash resources, by type (US$/t)

	August 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
Sulphate of potash	(6.58)	1.70	0.41	0.76	(3.16)	1.12	0.27	0.51	(6.44)	1.26	0.30	0.54
Muriate of potash	(0.40)	0.20	0.003	0.02	(0.84)	0.25	0.11	0.05	(2.76)	0.83	0.11	0.02
Brine	4.40	0.57	0.57	0.78	4.47	0.36	0.36	0.58	(2.16)	2.53	0.45	1.24

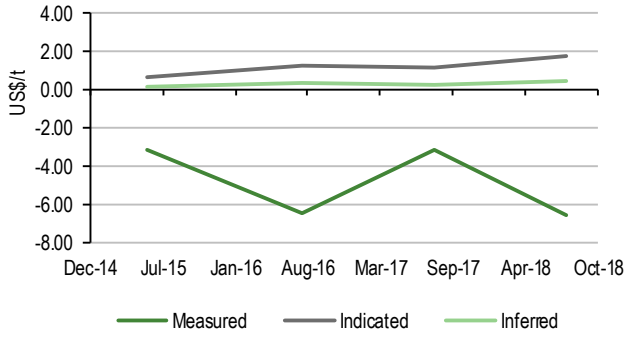
Source: Edison Investment Research

Sample sizes for each of the three subsectors are small. In addition, neither the SOP nor brine samples had companies or projects with inferred resources only, complicating the differentiated analysis. In the case of conventional SOP, therefore, the value attributed to inferred resources was deemed to be halfway between zero and the total average for companies with indicated & inferred resources only (ie halfway between their logical maximum value and their logical minimum value). In the case of brine, however, the value of inferred resources was assumed to be the same as the total average value for companies with indicated & inferred resources only (ie their maximum value, logically). In both cases, however, the results generated by these assumptions were consistent with historical results. In the case of conventional SOP, altering these assumptions does not materially change the pattern of the results for the values of measured, indicated and inferred resources, nor the qualitative conclusions arising therefrom. In the case of brine, however, while historically consistent, changing the assumption regarding the value of inferred resources does change the relative valuations of indicated and measured resources materially – the key difference being whether measured resources are valued at a premium to indicated resources or vice versa. Perhaps, in this case, therefore, the best conclusion that we may draw is that if inferred brine resources are valued at US$0.57/t, then blended measured & indicated resources are valued at US$1.38/t. If inferred brine resources are valued at US$0.29/t, then blended measured & indicated resources are valued at US$2.22/t. The obvious conclusion of either result is that (depending on cost) it is certainly worth brine companies upgrading resources from the inferred category, but given the constraints on our analysis, we are not yet able to definitively conclude whether upgrading them into the indicated or the measured category will be more value adding to their stock market listings.

Otherwise, a number of features of the analysis are noteworthy:

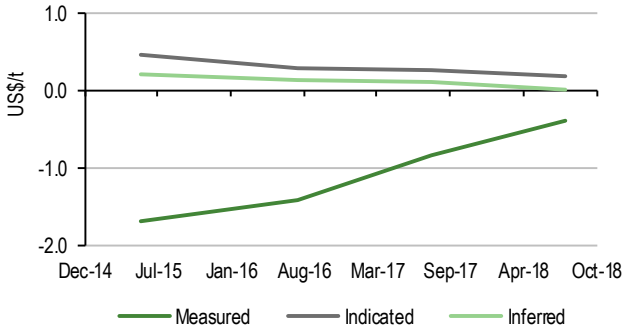
- Conventional SOP and MOP resources continue to exhibit a clear premium valuation for the indicated category of resources relative to the measured category.

Exhibit 65: In-situ value of SOP resources, by category, 2015–18 (US$/t)



Source: Edison Investment Research

Exhibit 66: In-situ value of MOP resources, by category, 2015–18 (US$/t)

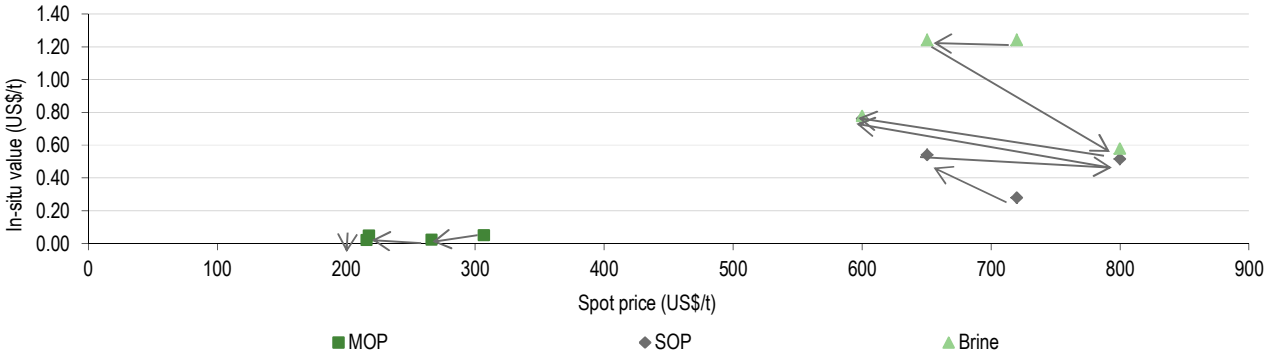


Source: Edison Investment Research

- On average, sulphate resources continue to attract a material premium valuation relative to muriate resources. However, there is a degree of overlap between the two samples, with the two highest rated MOP companies being afforded resource multiples that are higher than the lowest rated SOP company (note that each tonne of either SOP or MOP contains approximately comparable numbers of potassium units).
- While brine resources traded at a discernible premium to conventional SOP resources (on an undifferentiated basis) in August 2016, over the course of the past two years, this premium appears to have dissipated (see Exhibits 67 and 68).

Within the context of the commodity markets, it is notable that SOP resources (including brine) increased their valuation despite being in a falling market (arguably indicating that equity markets are anticipating a future rise in SOP prices), while MOP resources declined in value despite being in a relatively flat market (arguably indicating that they are anticipating a future fall in MOP prices).

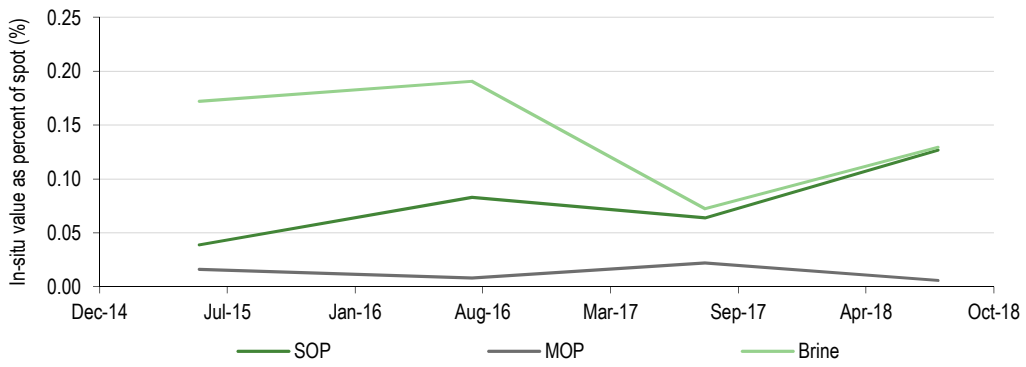
Exhibit 67: In-situ MOP, SOP and brine resource values (US$/t), 2015–18



Source: Edison Investment Research

As a result of these changes, SOP resources now trade at a widened premium, as a percentage of product prices, relative to MOP resources:

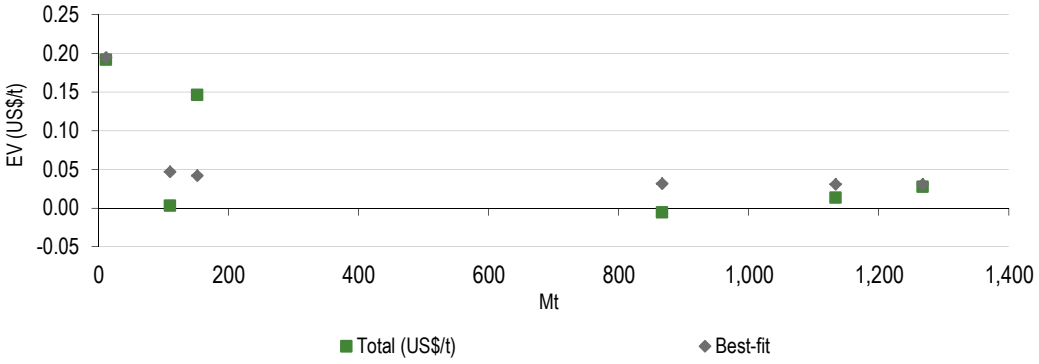
Exhibit 68: In-situ value of SOP, MOP and resources as a percentage of product prices, 2015–18 (US$/t)



Source: Edison Investment Research

While, in the past, the samples of all three subsections of the potash market were too small to draw any statistically significant conclusions regarding resource multiple and size, this year a statistically significant inverse relationship has emerged for the MOP subsector for a directional hypothesis (but not a non-directional one):

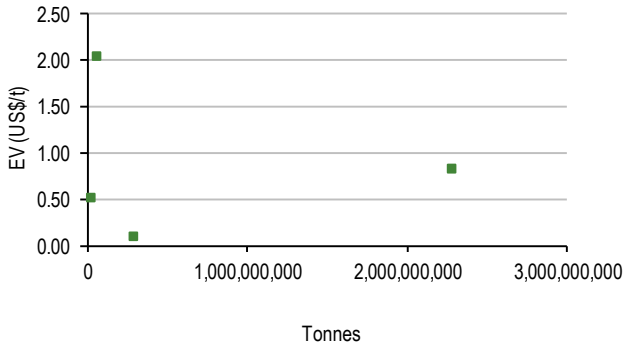
Exhibit 69: Resource size (Mt) vs resource multiple (US$/t) for MOP explorers



Source: Edison Investment Research

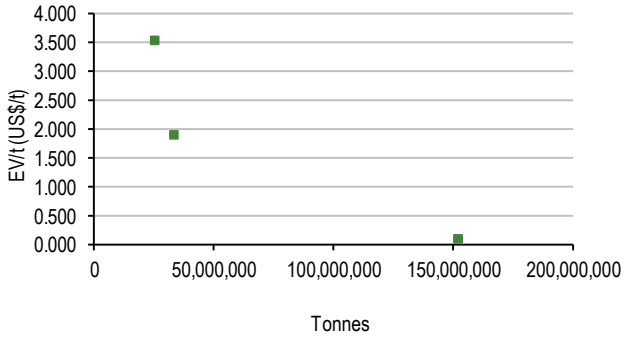
Anecdotally, the equivalent graphs for both SOP and brine could be interpreted as demonstrating an inverse relationship between resource multiple and resource size. In each case, however, the sample is too small to be regarded as mathematically significant:

Exhibit 70: Resource size (t) vs resource multiple (US$/t) for SOP explorers



Source: Edison Investment Research

Exhibit 71: Resource size (t) vs resource multiple (US$/t) for brine explorers



Source: Edison Investment Research

Potash multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the enterprise values (EVs) of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots the sample companies' EVs against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. In the case of the potash subsector, the sample for brine companies was too small to perform this analysis, while the sample for SOP companies was too small to provide any meaningful results. However, it was possible to perform the analysis on the MOP subsector, with the formula for resulting the best-fit line (in millions) being as follows:

EV = 12.2 − (0.094 × inferred tonnes) + (0.001 × indicated tonnes) + (0.550 × measured tonnes)

With the notable proviso that the above analysis includes a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. Unfortunately, in the case of MOP, this appears to be emphatically not the case, with the implication of the results of the analysis being that delineation of inferred resources is a value-destroying proposition for MOP explorers and the delineation of measured resources is strongly value adding – which is almost diametrically opposed to the results and implications of our in-situ analysis, above.

A summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above is as follows:

Exhibit 72: MOP explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	12.1839988	9.857875786	1.235965949	0.341939064	-30.2310174	54.599015
Inferred	-0.094408824	0.068905705	-1.37011621	0.304179419	-0.39088614	0.202068
Indicated	0.001380061	0.055032375	0.025077263	0.982270484	-0.23540514	0.238165
Measured	0.55040224	0.425891054	1.292354545	0.325412987	-1.28205907	2.382864

Source: Edison Investment Research

Readers are left to decide for themselves which analysis they prefer. In the case of the multiple regression analysis, however, it is worth noting that there is not a particularly high level of confidence in any of the factors calculated (as demonstrated by their relatively low t-stat results and their relatively high associated P-values). Therefore, while all of the values calculated in our in-situ analysis, above, fall within the ranges (lower 95% to upper 95%) derived from the multiple regression analysis, those ranges themselves are so wide that they effectively render themselves irrelevant.

Copper

While copper has spent much of the 13 months under review in a bull market, a late dip in the price since early June 2018 has resulted in the price actually having fallen since our analysis of in-situ values a year ago.

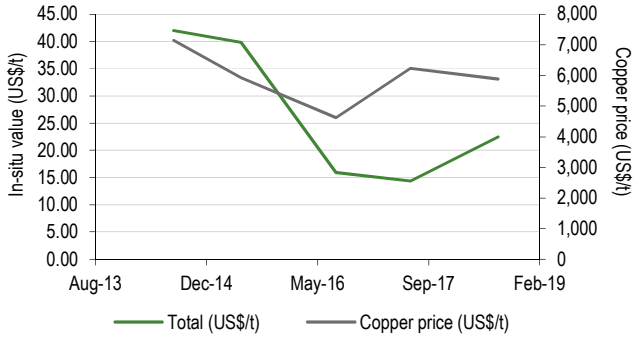
Exhibit 73: Global average in-situ value of explorers' copper resources (US$/t)

	August 2018				July 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ copper value (US$/t)	(269.56)	99.10	11.87	22.50	(59.00)	28.23	17.58	14.35	36.97	2.23	16.59	15.94

Source: Edison Investment Research, Thomson Reuters Datastream

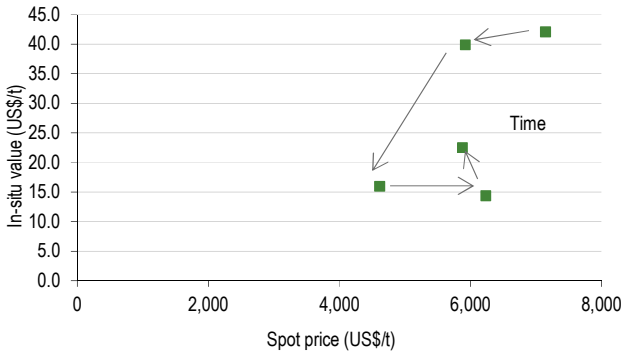
Notwithstanding this environment, blended average in-situ values rose during the period – in part, mitigating the decline in the previous year (despite a rising copper price environment) – albeit not to the levels prevailing the last time that copper was at a comparable level in June 2015 (see Exhibits 74 and 75).

Exhibit 74: In-situ value of copper resources and spot price of copper, 2014–18 (US$/t)



Source: Edison Investment Research

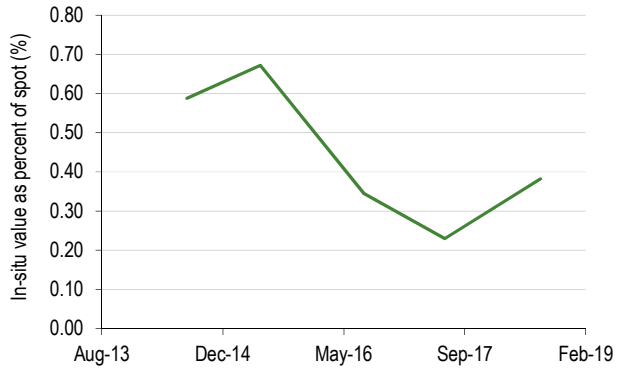
Exhibit 75: In-situ value of explorers' copper resources vs spot price of copper, 2014–18 (US$/t)



Source: Edison Investment Research

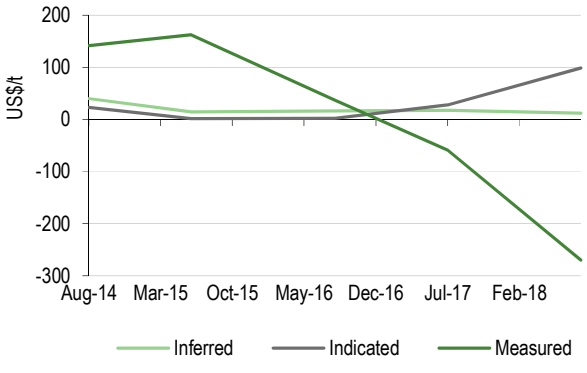
As a result, the average value of in-situ copper resources increased as a percentage of the copper price. For only the second time, the implied value of measured copper resources was also at a discount to that of indicated resources.

Exhibit 76: In-situ value of explorers' copper resources as percentage of spot price of copper, 2014–18 (US$/t)



Source: Edison Investment Research

Exhibit 77: In-situ value of copper resources vs spot price of copper, by category, 2014–18 (US$/t)

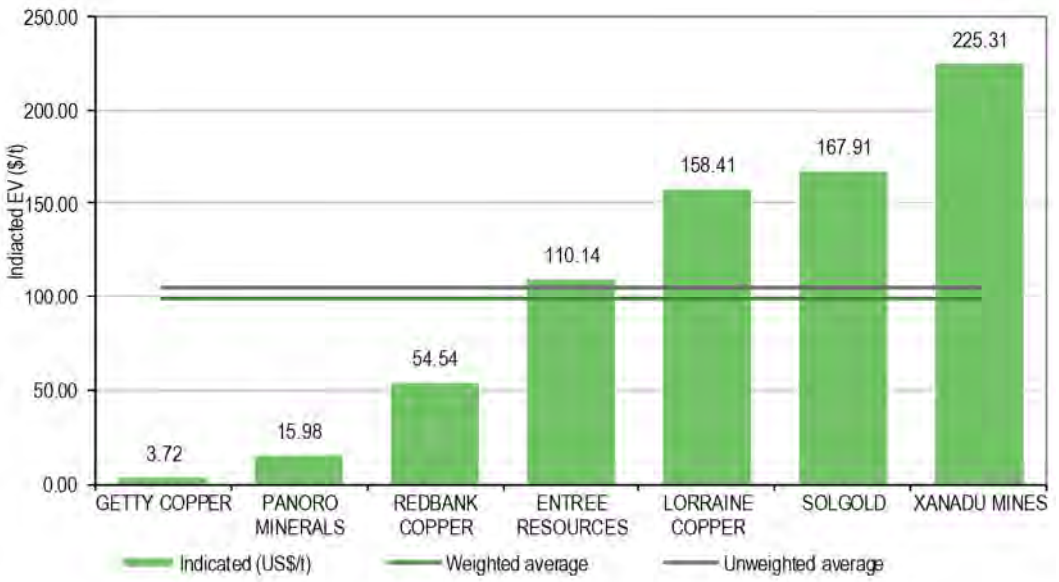


Source: Edison Investment Research

In part, this measured discount relative to the value of indicated resources could be attributed to the inclusion of SolGold in the population for the first time after its delineation of a maiden resource during the year. Even if it were to be excluded, however, the value of measured resources would still be at a discount to that of indicated resources (minus US$64.93/t vs plus US$43.43/t for indicated), albeit to a lesser extent. Nevertheless, there is little evidence that the inclusion of

SolGold in the sample of companies with indicated & inferred resources for the first time has unduly upset the analysis, with the implied value of its unique indicated resources lying within one standard deviation of the weighted average (which has, itself, converged satisfactorily with the unweighted average):

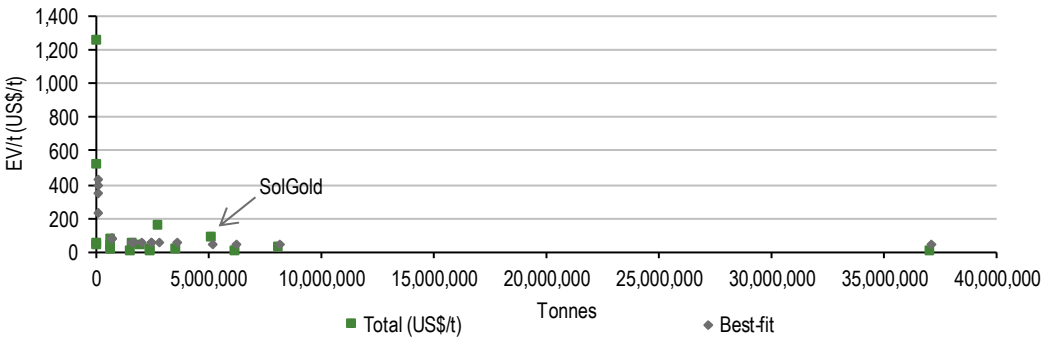
Exhibit 78: Implied in-situ value of indicated copper resources (US$ per total tonne)



Source: Edison Investment Research

In addition, SolGold's rating does not appear unduly anomalous when plotted within the context of the size of its resource, as shown below:

Exhibit 79: Graph of resource size (tonnes Cu) vs resource multiple (US$/t) for copper explorers



Source: Edison Investment Research

Note that the (inverse) correlation of resource size and multiple is statistically significant for a directional hypothesis (albeit not for a non-directional one) at the 5% level, unlike the equivalent analysis in 2017 which, while visually compelling, could not be said to have been statistically significant. This increases our confidence that equity markets are discounting a degree of future exploration success among copper explorers.

Copper multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its

measured, indicated and inferred resources. The multiple regression analysis therefore plots the sample companies' EVs against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. In the case of the copper subsector, the formula for the best-fit line (in millions) derived via such an analysis is as follows:

EV = 9.8 + (94.79 × inferred tonnes) − (46.41 × indicated tonnes) + (95.23 × measured tonnes)

With the notable proviso that the above analysis includes a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. Unfortunately, in the case of copper (as for MOP), this appears to be emphatically not the case, with the implication of the results of the multiple regression analysis being that the delineation of indicated resources is a value-destroying proposition and the delineation of measured and inferred resources is strongly value adding one for copper juniors – which is almost diametrically opposite the results and implications of our in-situ analysis, above.

A summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above is as follows:

Exhibit 80: Copper explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	9.768034367	46.94682771	0.208065909	0.837976212	-90.29676022	109.832829
Inferred	94.79294775	49.98703277	1.896350763	0.077342664	-11.75189053	201.337786
Indicated	-46.41356441	25.0161792	-1.855341859	0.083305823	-99.73428819	6.907159372
Measured	95.2327276	48.75135935	1.953437378	0.069679663	-8.678335143	199.1437903

Source: Edison Investment Research

Readers are left to decide for themselves which analysis they prefer. In the case of the multiple regression analysis, however, it is worth noting that there is a moderate (but less than 95%) level of confidence in the values of the factors calculated for measured, indicated and inferred resources (as demonstrated by their t-stat results approaching ±2 and their lowish associated P-values). However, there is a very low level of confidence relating to the value of the 'intercept'. Moreover, only the value for inferred resources in our in-situ analysis above falls within the range of values (lower 95% to upper 95%) derived from the multiple regression analysis, but the range is so wide that it effectively renders itself irrelevant.

Zinc (lead)

Zinc is often discovered in association with lead. For the purposes of our analysis of in-situ zinc values, all lead co-existing in the resource has therefore been converted into zinc equivalent (ZnE).

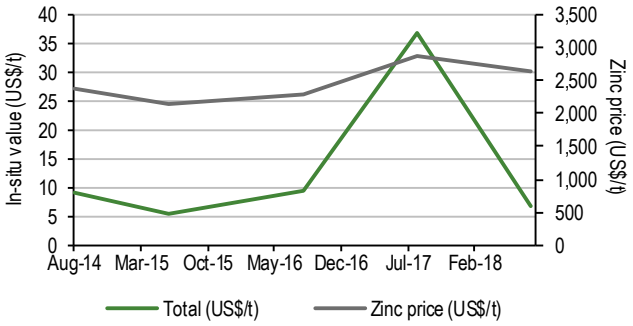
Exhibit 81: Global average in-situ value of explorers' zinc equivalent resources (US$/t)

	August 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ zinc value (US$/t)	2.83	8.08	7.23	6.79	185.94	14.27	11.13	36.90	(7.03)	14.02	10.85	9.45

Source: Edison Investment Research, Thomson Reuters Datastream

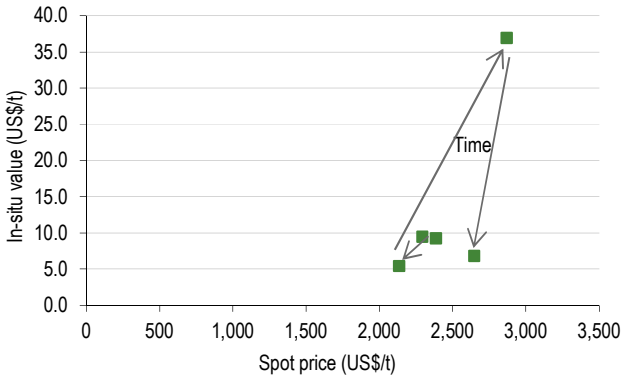
As in the copper market, conditions in the zinc market over the course of the 12 months under review were characterised by strength for the first 10½ months, followed by a period of discernible weakness from mid- to late-June 2018 onwards, which resulted in a sharp (and arguably, disproportionate) reduction in the value of in-situ resources over the period as a whole (see Exhibit 83, in particular):

Exhibit 82: In-situ value of zinc equivalent resources and spot price of zinc, 2014–18



Source: Edison Investment Research

Exhibit 83: In-situ value of zinc equivalent resources vs spot price of zinc, 2014–18



Source: Edison Investment Research

As a result, expressed as a percentage of the zinc price itself, the average value of in-situ zinc resources is within one percentage point of its recent nadir, in mid-2015, when the price of the metal was approximately 14% below its level of August 2018 when this analysis was conducted (see Exhibit 84).

One other notable feature of the analysis, in common with the previous year, is the fact that the vast majority of the decline in value in 2017/18 (reversing ostensibly all of the increase of the previous year) was concentrated among those companies with measured resources, rather than those with indicated and/or inferred resources (see Exhibit 85).

Exhibit 84: In-situ value of zinc equivalent resources as a percentage of the spot price of zinc, 2014–18

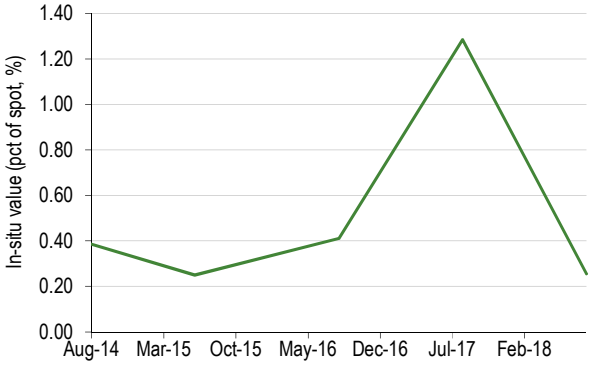
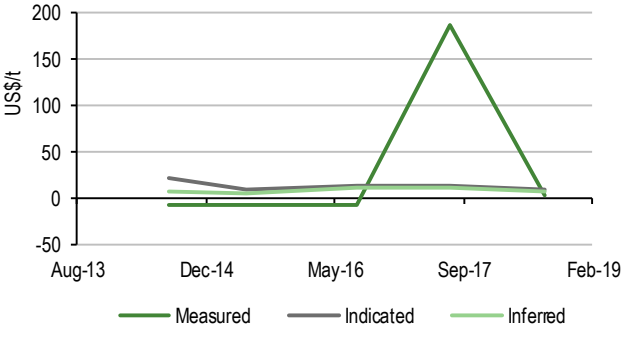


Exhibit 85: In-situ value of zinc equivalent resources, by category, 2014–18



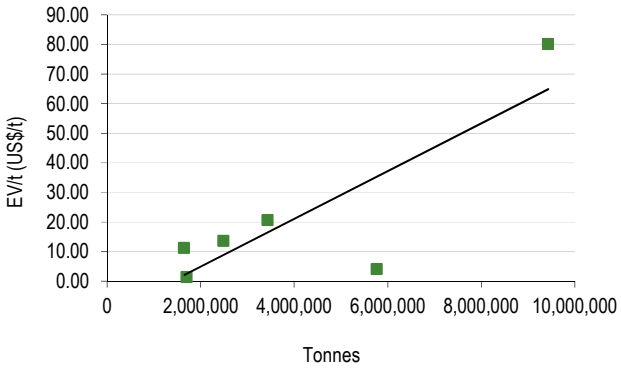
Source: Edison Investment Research

Source: Edison Investment Research

Where before, in 2017, it therefore profited zinc explorers to rapidly upgrade indicated and inferred resources into the measured category, in 2018 the situation has returned to the status quo ante whereby value is reserved in the lower confidence indicated and inferred categories of resources and the commercial imperative to upgrade resources into the measured category has evaporated.

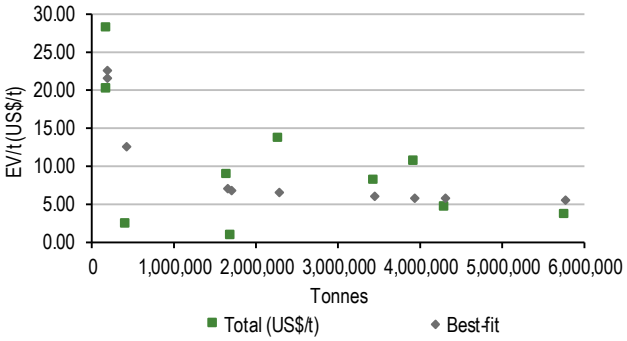
One other area in which the value of in-situ zinc resources has reverted to a more conventional pattern concerns the discounting of future blue-sky exploration success. Very unusually, in 2017, rather than apparently discounting future exploration success, investors in zinc assets appeared instead to be focused on the size and scale of the resource already delineated. As a result, larger resources attracted larger in-situ resource multiples. In 2018, however, this has now reverted to the more conventional relationship, whereby smaller deposits on average attract larger in-situ resource multiples, suggesting that the market is attaching tangible value to the probability of increasing the size of the resource via ongoing exploration work.

Exhibit 86: Graph of resource size (t) vs resource multiple (US$/t) for zinc explorers, 2017



Source: Edison Investment Research

Exhibit 87: Graph of resource size (t) vs resource multiple (US$/t) for zinc explorers, 2018



Source: Edison Investment Research

Note that the (inverse) correlation of resource size and multiple in Exhibit 87 is statistically significant at the 5% level for all hypotheses, both directional and non-directional, in 2018.

Last year, by contrast (Exhibit 86), exhibited a very strong (Pearson product moment coefficient of 0.83) and statistically significant direct positive correlation between resource size and multiple.

Zinc multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots the EVs of the companies in each subsector against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. In the case of the zinc subsector, the formula for the best-fit line (in millions) derived via such an analysis is as follows:

EV = 4.8 + (2.36 × inferred tonnes) + (6.73 × indicated tonnes) + (4.38 × measured tonnes)

With the notable proviso that the above analysis includes a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. In general, this may be regarded as approximately true. In the case of zinc resources, it is particularly notable that the highest values in both analyses are afforded to the indicated category, suggesting that upgrading to this category (but

no further) is, depending on cost, the best way in which zinc explorers' managements can add value to their companies.

A summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above is as follows:

Exhibit 88: Zinc explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	4.824280784	6.146200861	0.784920782	0.462357332	-10.21493094	19.86349251
Inferred	2.364593585	3.507265143	0.674198696	0.525294079	-6.217375059	10.94656223
Indicated	6.734488087	3.494984911	1.926900475	0.102282826	-1.817431912	15.28640809
Measured	4.381544715	5.201691312	0.842330783	0.43189082	-8.346535403	17.10962483

Source: Edison Investment Research

In the case of this analysis specifically, while it is noticeable that there is a fair degree of doubt regarding the values of the factors relating to the 'intercept', inferred and measured resources, there is, in fact, a moderate level of confidence (as evidenced by its relatively large t-stat values and relatively small associated P-values) attached to the factor relating to indicated resources (thus reinforcing our prior conclusions, relatively speaking).

Readers should also note that all of the values for measured, indicated and inferred resources calculated in our in-situ analysis, above, fall within the ranges (lower 95% and upper 95%) implied by the multiple regression analysis (see Exhibit 88, above) – again conferring confidence in the results of the two processes and the conclusions arising therefrom.

Lithium

As with our nickel and potash analyses, our lithium analysis has been subdivided, with Western Australian (WA) companies with spodumene resources being distinguished from the remainder of the sector.

Exhibit 89: Global average in-situ value of explorers' lithium resources (US$/t)

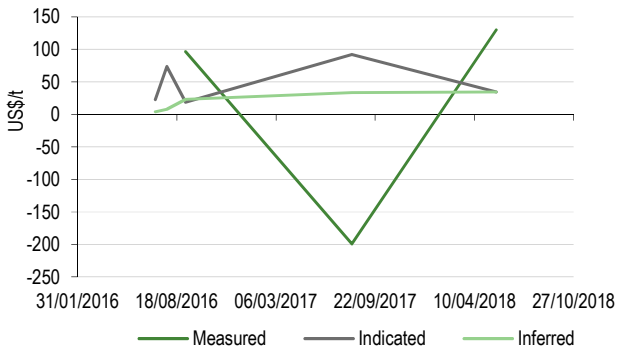
US$/t	May 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ lithium value	130.16	34.55	34.55	53.84	(198.89)	92.33	33.43	39.16	96.47	18.51	23.17	25.72
WA spodumene co's	308.80	216.45	216.45	222.61	(206.47)	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.

For both sample groups, the analysis was complicated by a lack of companies with inferred resources only. In the case of Western Australian spodumene explorers, however, there was a very tight grouping of valuations around the US$222/t level for all companies with all combinations and permutations of resource categorisation. As a result, we decided to assign a value to inferred resources that was the same for the blended average for companies with both inferred and indicated resources (ie the logical maximum value for inferred resources, generating close to the logical minimum value for indicated resources). Either way, however, for this subsection of companies, the values of each category of resources has increased regardless. Conducting a sensitivity analysis on the results also suggests that it would be illogical for the value of inferred resources to be below US$193.78/t, in which case the value of indicated resources would be US$252.54/t and the value of measured resources would be US$222.61/t. However, the same analysis also suggests that the value of indicated resources should not exceed US$234.34/t.

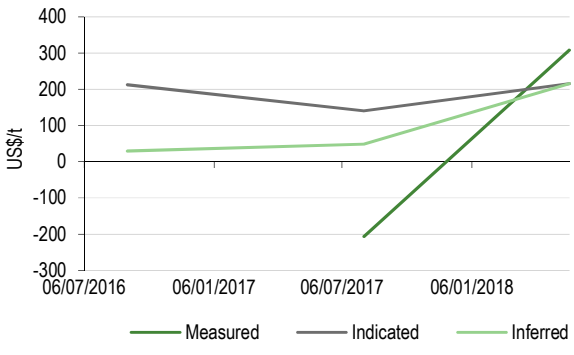
In the case of the remainder of the sector, there was one company with inferred resources only. However, this was discounted for the purposes of the wider analysis, as it was a clear statistical outlier in terms of its resource multiple. In order to define a discrete value for inferred resources therefore, we once again assigned a value equivalent to the blended average for companies with both inferred and indicated resources (ie the logical maximum value for inferred resources, generating the logical minimum value for indicated resources). While alternative treatments of the data were available to us, under almost any circumstances it was apparent that the values of inferred and indicated resources had been stable or declined over the course of the year in question, while the value of measured resources had increased. As such, in contrast to the previous year, in both subsections of the market, there has been a shift in valuation in favour of late-stage, higher-confidence (ie measured) resources at the expense of early-stage, lower confidence ones.

Exhibit 90: Lithium explorers, in-situ value by resource category 2016–18 (US$/t)



Source: Edison Investment Research

Exhibit 91: Western Australian spodumene explorers, in-situ value by resource category 2016–18 (US$/t)

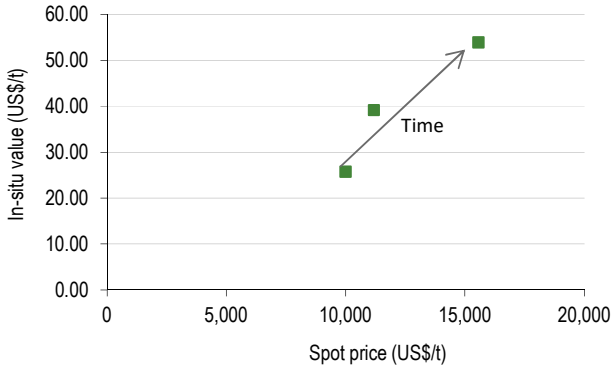


Source: Edison Investment Research

By coincidence, our analysis of in-situ lithium values was conducted almost exactly at the top of the market in terms of the lithium carbonate price, helping to drive in-situ valuations higher. The other

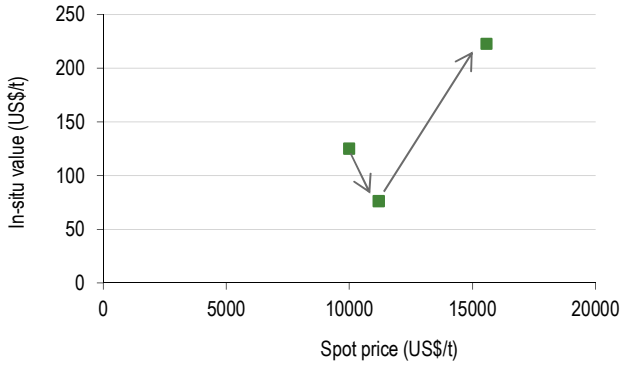
notable feature of the analysis is the reassertion of the Western Australian spodumene explorers' premium valuation compared with the broader sector to levels last seen in c August 2016.

Exhibit 92: Lithium explorers' average in-situ value vs lithium carbonate spot price, 2016–18 (US$/t)



Source: Edison Investment Research

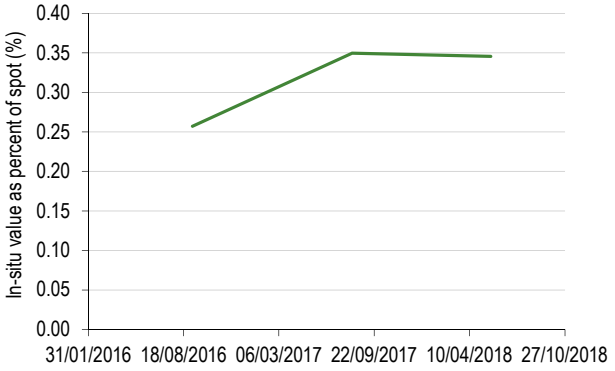
Exhibit 93: Western Australian spodumene explorers, in-situ value vs lithium carbonate spot price, 2016–18 (US$/t)



Source: Edison Investment Research

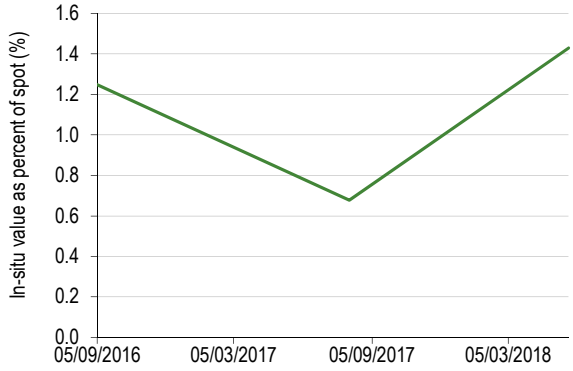
While Western Australian spodumene explorers' ratings therefore increased (back to, or even above, the levels of August 2016), on average, as a percentage of the spot price of lithium carbonate, those for the remainder of the sector remained, more or less, static:

Exhibit 94: Lithium explorers' average in-situ value as a percentage of the lithium carbonate spot price, 2016–18 (%)



Source: Edison Investment Research

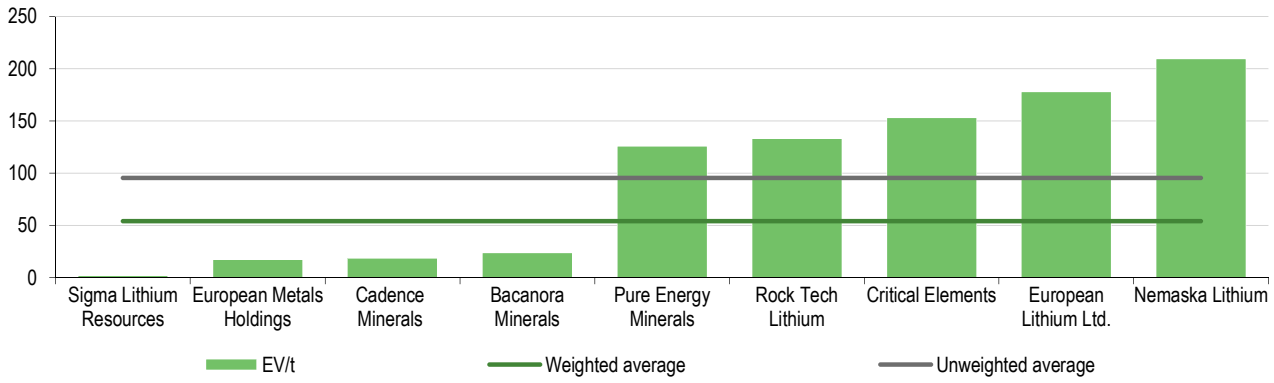
Exhibit 95: Western Australian spodumene explorers, in-situ value as a percentage of the lithium carbonate spot price, 2016–18 (%)



Source: Edison Investment Research

Simultaneously, considered on an undifferentiated basis (below), there is continued evidence of a discounted valuation being accorded to clay and clay-like deposits (eg Bacanora, Cadence and European Metals Holdings) and a median valuation being accorded to brines (eg Pure Energy). It is also notable that, on this basis, those companies that are arguably the most advanced in terms of developing mining operations are also the most highly rated.

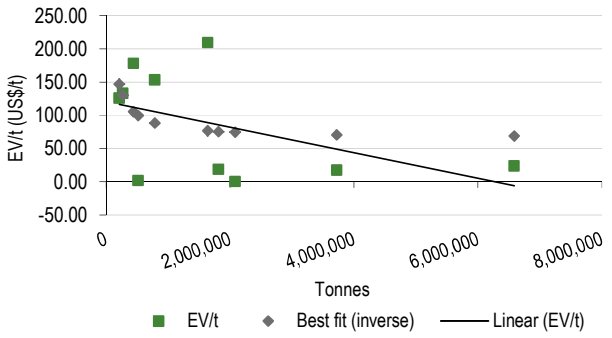
Exhibit 96: Implied in-situ value of lithium resources (US$ per total tonne)



Source: Edison Investment Research

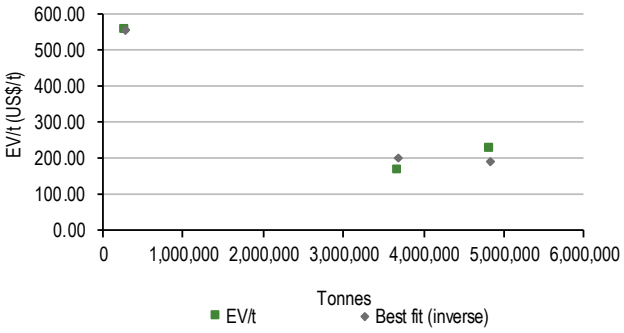
For both subsections of the population there is also anecdotal evidence that the market appears to discount some degree of future exploration success. In the case of Western Australian spodumene companies, however, the sample size is too small for the statistical data to be meaningful. In the case of the remainder of the sector, by contrast, neither the inverse relationship observed between resource size and resource multiple nor the linear relationship can be said to be statistically significant (at the 5% level).

Exhibit 97: Graph of resource size (t) vs resource multiple (US$/t) for lithium explorers



Source: Edison Investment Research

Exhibit 98: Graph of resource size (t) vs resource multiple (US$/t) for Western Australian spodumene explorers



Source: Edison Investment Research

Lithium multiple regression analysis

No multiple regression analysis was performed for lithium juniors in 2018. We hope to add this in future years.

Graphite

Overall, in-situ graphite values in the 12 months under review generally experienced a slight easing, notwithstanding an approximately flat graphite market.

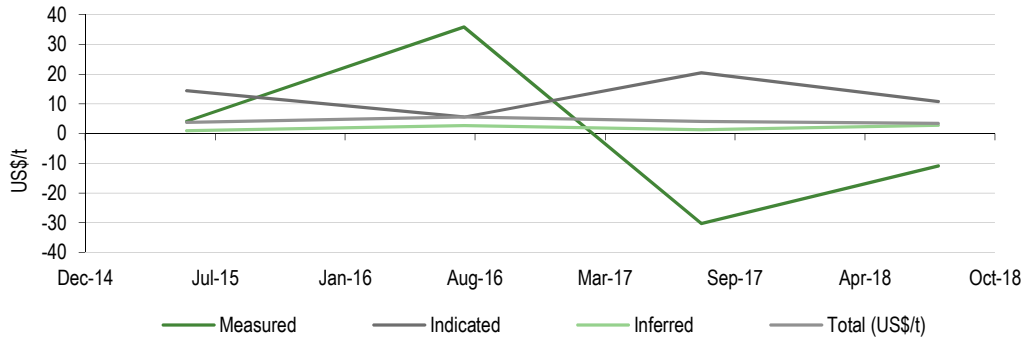
Exhibit 99: Global average in-situ value of explorers' graphite resources (US$/t)

	August 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ graphite value (US$/t)	(10.83)	10.73	2.80	3.41	(30.31)	20.51	1.29	4.02	36.10	11.38	2.01	6.42

Source: Edison Investment Research, Thomson Reuters Datastream

The in-situ graphite analysis was complicated by the fact that there was only one company with inferred resources only, and that company's resource was very small and its resource multiple therefore preternaturally high. As a result, we deemed the value of inferred graphite resources to be halfway between zero and the blended average value of total resources for companies with indicated & inferred resources only. Nevertheless, regardless of the value ascribed, under almost any (logical) circumstances, the pattern whereby the value of indicated resources was approximately US$11/t and the value of measured resources was negative was maintained. At an inferred value of zero, for example, the value of indicated resources was seen to be US$15.88/t and the value of measured resources was seen to be minus US$14.80/t. At the other end of the spectrum, an inferred value of US$5.59/t implied a value for indicated resources of US$5.59/t and a value for measured resources of minus US$6.80/t. As such, it can be stated with reasonable certainty that the value of indicated resources moderated during the year and the value of measured resources increased, albeit from an historically low level – which is almost exactly the reverse of the pattern observed between 2016 and 2017 (then within the context of a declining graphite market).

Exhibit 100: In-situ value of graphite resources, by category, and graphite price 2015–18 (US$/t)

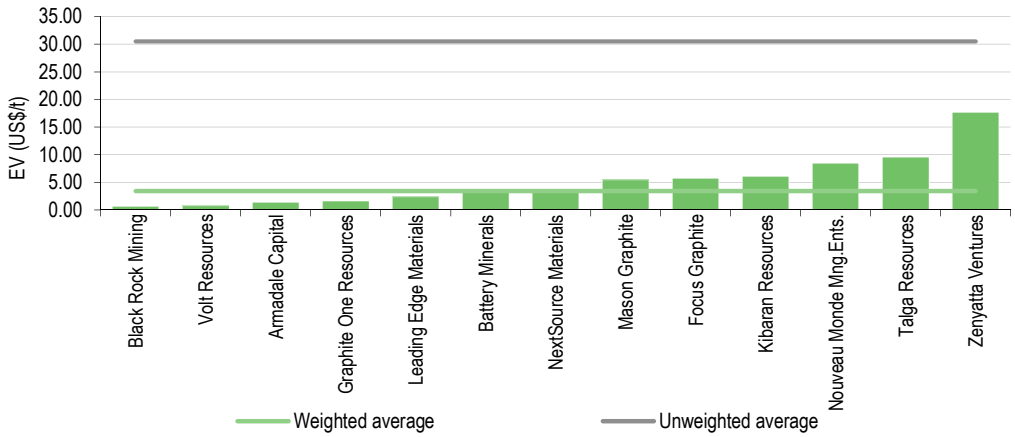


Source: Edison Investment Research

In consequence, therefore, it is likely to remain a value-destroying proposition for management in junior graphite explorers to upgrade their resources from indicated to measured status.

However, unlike in previous years, when there appeared to be two distinct groups within the population (a highly rated group and a low-rated group), this distinction now appears to have dissipated within the context of the undifferentiated analysis:

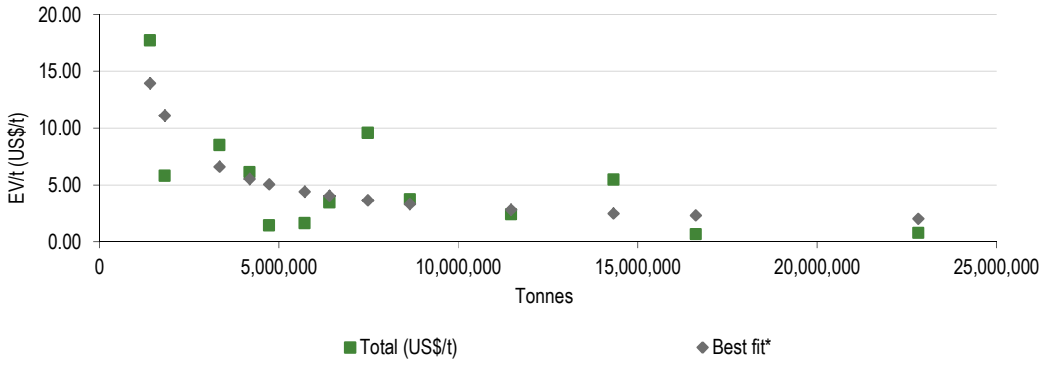
Exhibit 101: Implied in-situ value of graphite resources (US$ per total tonne), August 2018



Source: Edison Investment Research. Note: Chart excludes Canada Carbon.

Notwithstanding other changes, however, the pattern whereby a small resource is associated with a high rating has been strongly maintained (and, arguably, reinforced), providing strongly statistically significant evidence for the continued discounting of future resource discoveries by equity markets:

Exhibit 102: Graph of resource size (t) vs resource multiple (US$/t) for graphite explorers



Source: Edison Investment Research. Note: *Excludes Carbon Canada.

Graphite multiple regression analysis

No multiple regression analysis was performed for graphite juniors in 2018. We hope to add this in future years.

Tungsten

While the tungsten price (in the form of ammonium paratungstate, or APT) has recently given up some of its gains, in the 12-month period under review, it was the second best performing of all the metals we profile in this report – not least in response to moves in the oil price over the same period and the related Baker Hughes rig count index, which it tracks closely owing to its applications in the drilling industry.

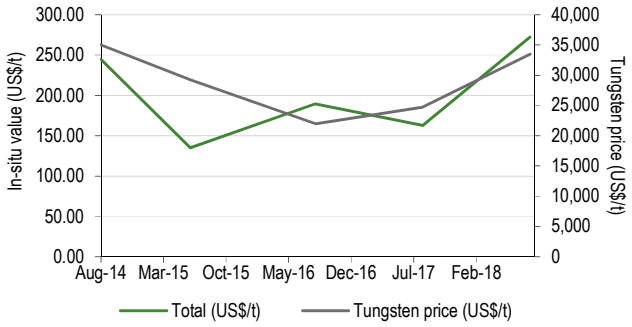
Exhibit 103: Global average in-situ value of explorers' tungsten resources (US$/t)

	August 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ tungsten value	622.60	294.30	154.27	272.29	1,251.59	100.87	108.47	162.90	1,627.68	368.47	89.59	189.60

Source: Edison Investment Research, Thomson Reuters Datastream

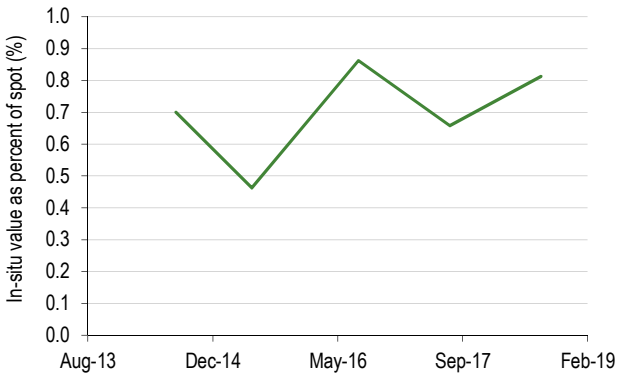
However, notwithstanding the increase in in-situ values, they are little more than would be expected given the rise in the APT price itself. In fact, as a percentage of the APT price, in-situ values are still below their level in August 2106.

Exhibit 104: Global average in-situ value of explorers' tungsten resources (US$/t) and APT price (US$/t), 2014–18



Source: Edison Investment Research

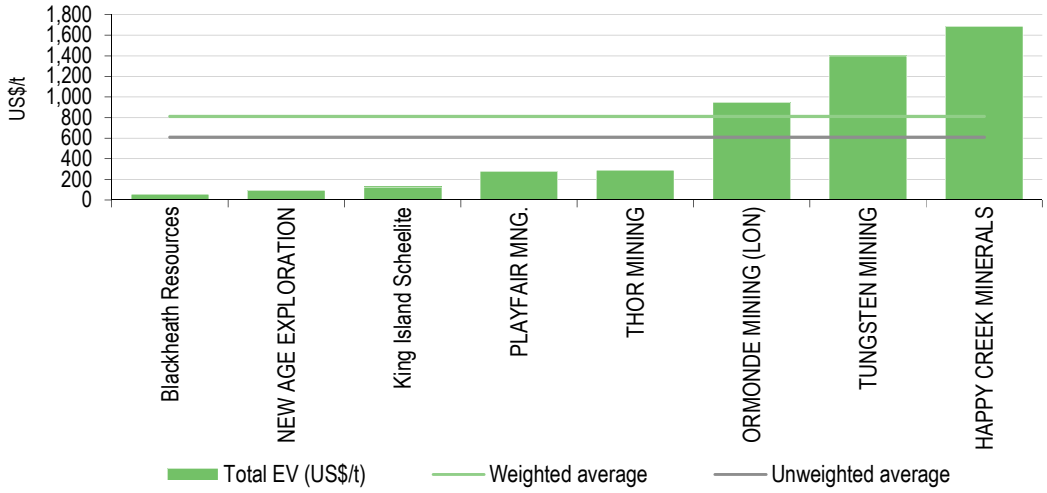
Exhibit 105: Global average in-situ value of explorers' tungsten resources (US$/t) as percentage of APT price (US$/t), 2014–18



Source: Edison Investment Research

In the case of tungsten, our differentiated analysis was complicated by two companies, namely Tungsten Mining and Happy Creek Minerals, both of which proved to be statistical outliers as far as the valuation of indicated resources, in particular, was concerned. As a consequence, the results shown in Exhibit 103, above (and in the rest of this report), exclude these two companies, albeit for no reason other than the fact that they attract valuations which cannot be easily explained within the context of the balance of the sector, other than by their projects' unique technical characteristics. Note, however, that their ratings can be explained on an undifferentiated basis – perhaps suggesting that the global equity markets make no valuation distinction between categories of resources among tungsten explorers. Were these two companies to be included in the analysis, the average in-situ value of tungsten resources would increase by almost three times, to US$811.13/t, and the value of indicated resources would increase by approximately 10 times (with a concomitantly deleterious effect on the associated value of measured resources).

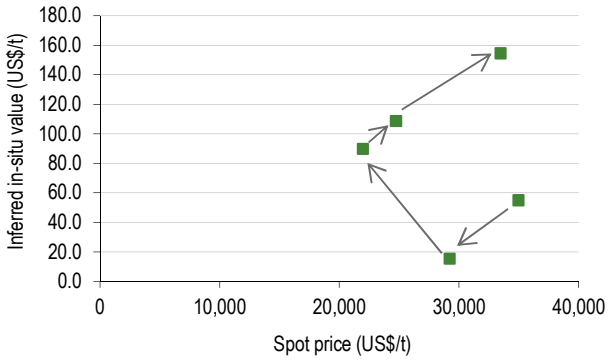
Exhibit 106: In-situ value of explorers' tungsten resources, by company (US$/t)



Source: Edison Investment Research

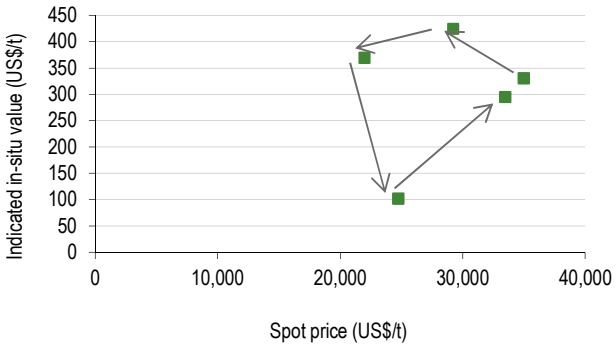
Excluding these two companies, however, almost all of the values for the individual categories plus the overall average values for in-situ resources as a whole are where we would expect them to be, given the price of APT at the time of the analysis and historical experience, with the exception of those resources in the inferred category (which are somewhat higher than in the recent past – see Exhibit 107) and those in the measured category (which are somewhat lower, but very much of the same order of magnitude – see Exhibit 109):

Exhibit 107: Value of explorers' inferred in-situ tungsten resources (US$/t) vs APT price (US$/t), 2014–18



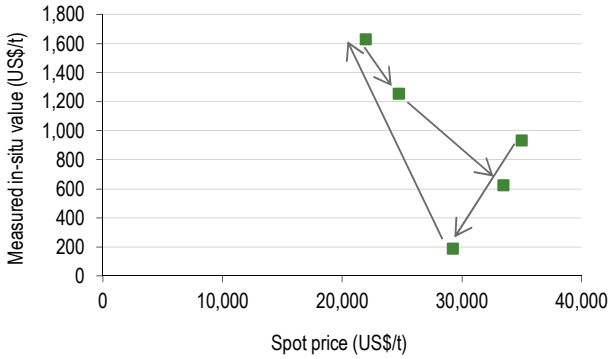
Source: Edison Investment Research

Exhibit 108: Value of explorers' indicated in-situ tungsten resources (US$/t) vs APT price (US$/t), 2014–18



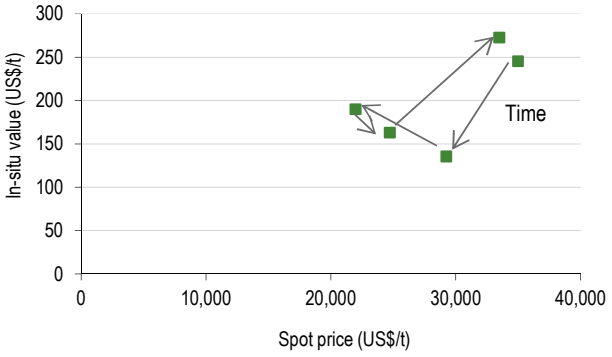
Source: Edison Investment Research

Exhibit 109: Value of explorers' measured in-situ tungsten resources (US$/t) vs APT price (US$/t), 2014–18



Source: Edison Investment Research

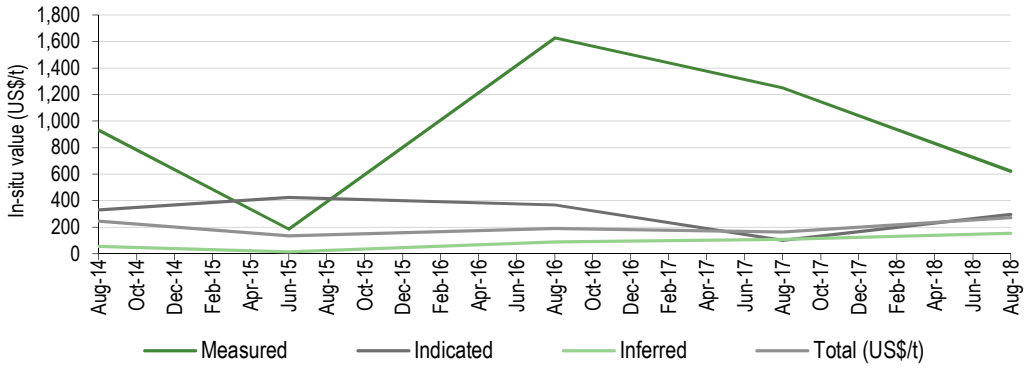
Exhibit 110: Value of explorers' in-situ tungsten resources (US$/t) vs APT price (US$/t), 2014–18



Source: Edison Investment Research

Over time, the evolution of the values of the three different resource categories can be seen, as shown in Exhibit 109.

Exhibit 111: In-situ value of tungsten resources differentiated by category, 2014–18

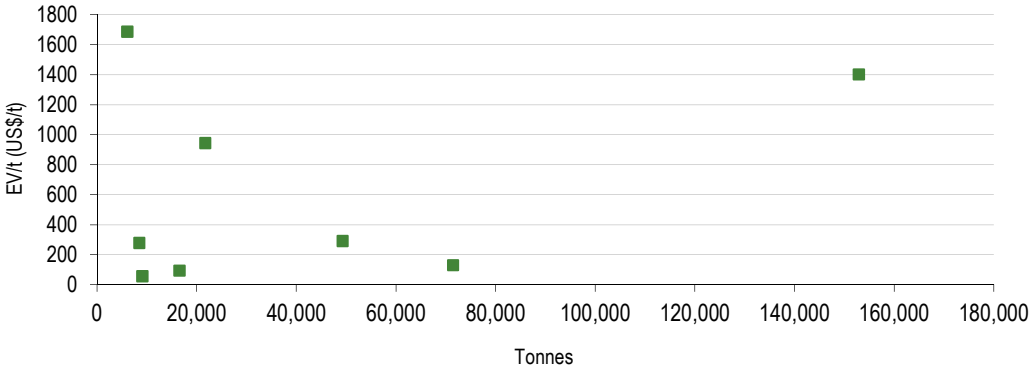


Source: Edison Investment Research

One potential conclusion of this analysis (albeit not statistically significant) is that, at first glance, the values of measured and inferred resources appear to have a negative correlation with the price of APT, whereas indicated and average resources appear to have a positive correlation. In addition, the range of potential values for both measured and inferred resources (9x and 10x from minimum to maximum, respectively) is materially larger than the range of potential values for indicated resources (four times from minimum to maximum, respectively).

As in 2017, 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 are weak (ie not statistically significant) and the nature of the relationship (eg inverse or linear) difficult or impossible to determine:

Exhibit 112: Graph of resource size (t) vs resource multiple (US$/t) for tungsten explorers



Source: Edison Investment Research. Note: Tungsten Mining and Happy Creek Minerals included.

Tungsten multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots EVs of the companies in each subsector against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. In the case of the tungsten subsector (excluding Tungsten Mining and Happy Creek), the formula for the best-fit line (in millions) derived via such an analysis is as follows:

EV = -3.5 + (682 × inferred tonnes) + (55 × indicated tonnes) + (2,704 × measured tonnes)

Including Tungsten Mining and Happy Creek, the formula is:

EV = -10.7 + (1,802 × inferred tonnes) + (85 × indicated tonnes) + (2,920 × measured tonnes)

With the notable proviso that the above analysis includes a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. In magnitude, this could probably not be said to be true. However, the multiple regression analysis does support our earlier in-situ analysis inasmuch as it suggests that adding resources in any category can be value adding to tungsten explorers. In addition, it supports our time-based observation that companies' enterprise values could prove more sensitive to changes in the measured and inferred categories of resources rather than in the indicated category.

A summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above (excluding Tungsten Mining and Happy Creek) is as follows:

Exhibit 113: Tungsten explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	-3.48332744	11.35443767	-0.30678115	0.788004	-52.337530	45.370875
Inferred	681.9223284	929.290237	0.733809849	0.539429	-3316.491	4680.336
Indicated	55.31990234	161.0420882	0.343512078	0.763964	-637.5883	748.2281
Measured	2704.429003	1782.308332	1.517374381	0.268463	-4964.225	10373.08

Source: Edison Investment Research. Note: Excludes Tungsten Mining and Happy Creek Minerals (see text).

In the case of this analysis specifically, it is noticeable that, while there is a fair degree of doubt regarding all of the other factors, the most confidence relates to the factor applied to measured resources.

In the meantime, a summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above (including Tungsten Mining and Happy Creek) is as follows:

Exhibit 114: Tungsten explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	-10.6539873	6.661198519	-1.59940996	0.184978	-29.148439	7.840465
Inferred	1802.091862	131.2348895	13.73180462	0.000163	1437.7254	2166.458
Indicated	85.49177217	241.7250453	0.353673621	0.741438	-585.6445	756.6281
Measured	2920.254755	2442.844971	1.195431879	0.297944	-3862.17	9702.68

Source: Edison Investment Research. Note: Include Tungsten Mining and Happy Creek Minerals (see text).

As in the previous analysis, it is noticeable that there is a modicum of confidence relating to the factor applied to measured resources. There is also a degree of confidence relating to the 'intercept'. However, most strikingly, there is a high degree of confidence relating to the factor applied to inferred resources – further reinforcing our prior conclusions that, in the case of tungsten explorers, most unusually, in order to add value to their enterprises, companies should focus on increasing resources in both the measured and inferred categories, rather than the indicated category.

Vanadium

After more than doubling in 2016/17, the price of vanadium (in the form of vanadium pentoxide, V_2O_5) performed the same trick in 2017/18, rising from US$9.50/lb (US$20,948/t) in August 2017 to US$20.5/lb (US$45,203/t) in August 2018, and was by far the best performing metal within our subject group over the course of the year (see Exhibit 17).

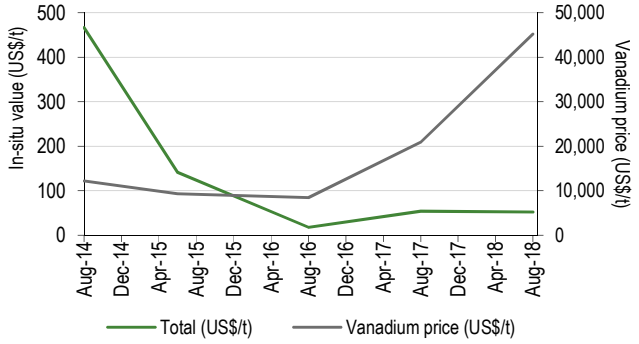
Exhibit 115: Global average in-situ value of explorers' vanadium resources (US$/t)

	August 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ vanadium value (US$/t)	213.26	117.99	8.48	52.31	205.49	56.40	21.37	54.40	135.15	(6.73)	9.64	18.01

Source: Edison Investment Research, Thomson Reuters Datastream

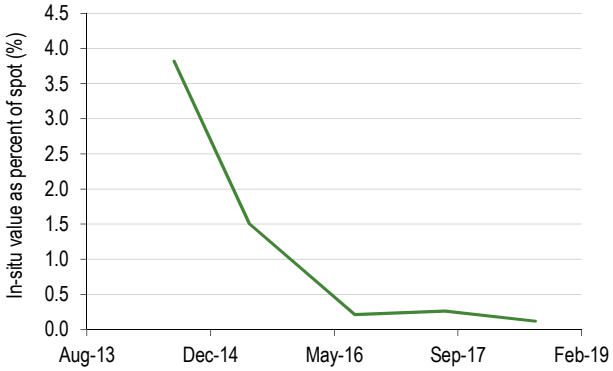
Notwithstanding the rise in the metal price, however, after rising strongly between August 2016 and August 2017, between August 2017 and August 2018, there was hardly any response in average in-situ vanadium values to the rise in the metal price, with the result that (expressed as a percentage of the metal price) vanadium explorers appear some of cheapest in the mining universe, excepting bulk commodities (see Exhibits 4 and 139).

Exhibit 116: In-situ value of vanadium resources and vanadium spot price, 2014–18



Source: Edison Investment Research

Exhibit 117: In-situ value of vanadium resources as a percentage of spot price of vanadium, 2014–18

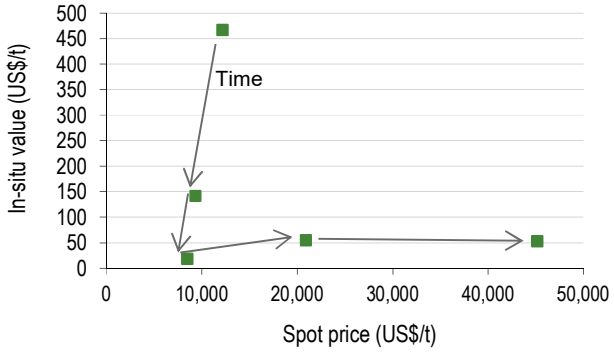


Source: Edison Investment Research

The analysis of in-situ vanadium resources was complicated by the population of vanadium explorers being small, there being one company with inferred resources only and no companies with indicated & inferred resources only. However, the company with inferred resources only yielded a value for inferred resources that was in line with recent historical experience. In order to determine the valuation of discrete indicated resources, we calculated a value halfway between the blended average value of total resources (the logical minimum value for indicated resources at which the value of indicated resources equals that of inferred) and the blended average value of measured and indicated resources (the logical maximum, at which the value of indicated resources equals that of measured).

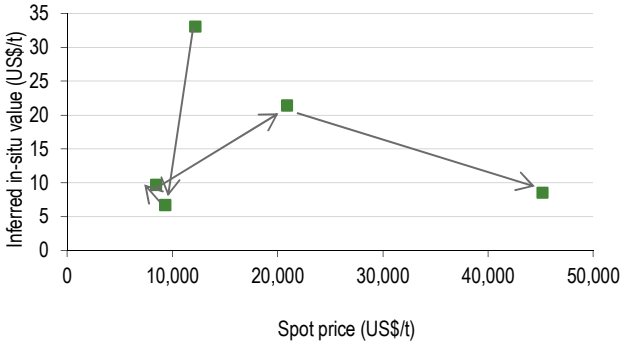
Notwithstanding these assumptions, this methodology generated results that were more accurate in explaining the valuations of junior vanadium explorers than a simple reliance on total resources. Other conclusions are that indicated vanadium resources have a greater valuation range than those for either measured or inferred resources (see Exhibits 118–121, overleaf) and that there is a closer correlation between the value of indicated resources and the spot price (statistically significant at the 5% level for a directional hypothesis) than for measured and inferred resources (for which the correlation could not be said to be statistically significant).

Exhibit 118: In-situ value of vanadium resources vs vanadium spot price, 2014–18



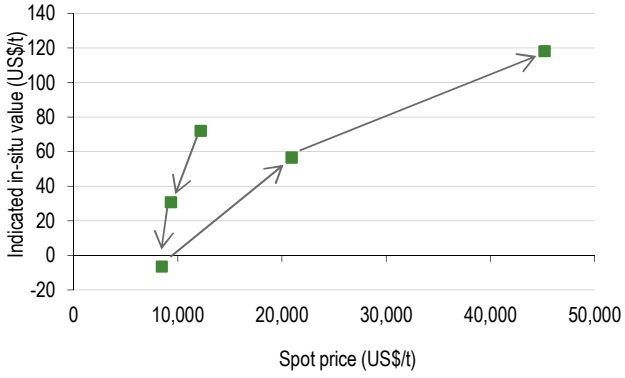
Source: Edison Investment Research

Exhibit 119: In-situ value of inferred vanadium resources vs vanadium spot price, 2014–18



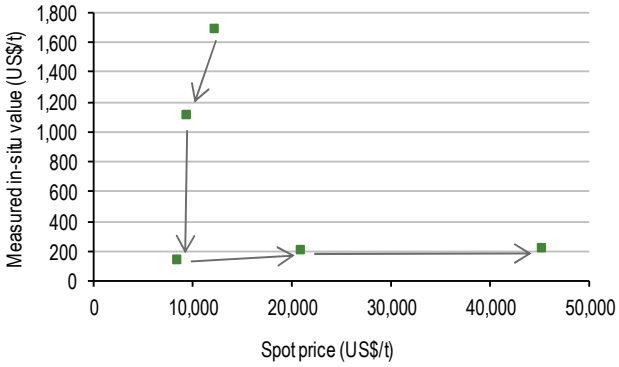
Source: Edison Investment Research

Exhibit 120: In-situ value of indicated vanadium resources vs vanadium spot price, 2014–18



Source: Edison Investment Research

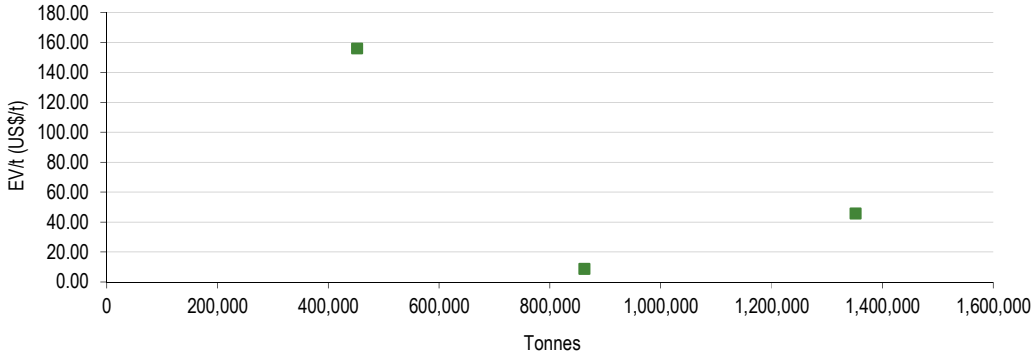
Exhibit 121: In-situ value of measured vanadium resources vs vanadium spot price, 2014–18



Source: Edison Investment Research

Note that there is possibly some anecdotal and visual evidence of the market discounting future resource discoveries (see Exhibit 122, below), but this must be considered as non-statistically significant given the number of data points in the population:

Exhibit 122: Graph of resource size (t) vs resource multiple (US$/t) for vanadium explorers



Source: Edison Investment Research

Vanadium multiple regression analysis

No multiple regression analysis was performed for vanadium juniors in 2018. We hope to add this in future years.

Metallurgical coal

After losing 82% of their value between August 2016 and August 2017, the 12 months to August 2018 were characterised by a 226% recovery in the value of average metallurgical coal resources despite a slight easing in the price of metallurgical coal itself on world markets.

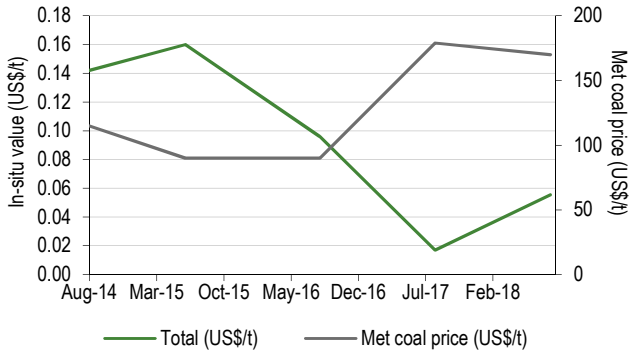
Exhibit 123: Global average in-situ value of explorers' metallurgical coal resources (US$/t)

	August 2018				August 2017				August 2016			
	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total	Measured	Indicated	Inferred	Total
In-situ metallurgical coal value (US$/t)	0.165	0.065	0.019	0.055	No data	No data	No data	0.017	5.87	0.04	0.01	0.10

Source: Edison Investment Research, Thomson Reuters Datastream

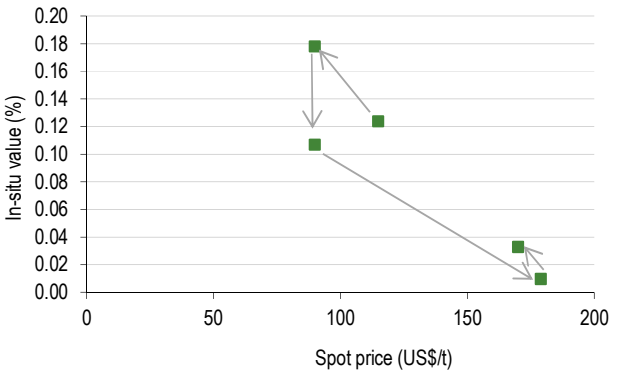
While large in percentage terms, however, the increase only partially recovers the declines of the previous year, either in percentage or nominal terms.

Exhibit 124: In-situ value of metallurgical coal resources vs spot price, 2014–18



Source: Edison Investment Research. Note: Historic metallurgical coal prices restated to reflect single, standardised contract.

Exhibit 125: In-situ value of metallurgical coal resources as a percentage of the spot price, 2014–18

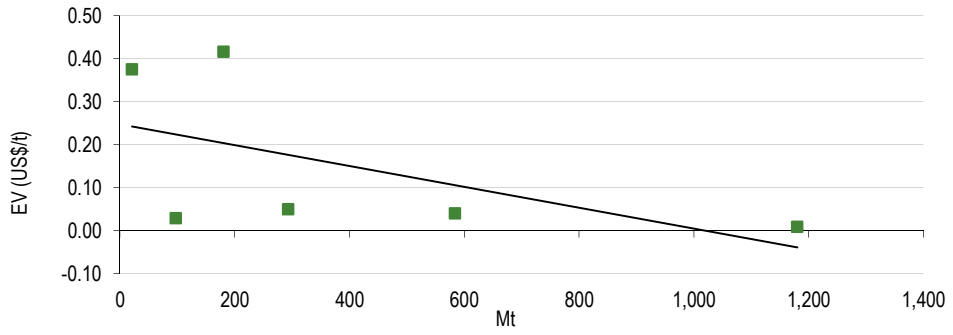


Source: Edison Investment Research. Note: Historic metallurgical price restated to reflect single, standardised contract.

As in previous years, the analysis of metallurgical coal resource values was complicated by the fact that there were no companies or projects that had inferred resources only. In addition, more junior metallurgical coal explorers were identified to add to the population being analysed, with the result that the shortcoming of the analysis in 2017, whereby there were no companies with either inferred resources only or indicated & inferred resources only, was overcome. As in other subsectors, we ascribed a value to inferred resources that was halfway between zero (its logical minimum) and the blended average of resources for companies with indicated & inferred resources only (its logical maximum, at which point the value of inferred resources is equal to that of indicated resources).

Anecdotally, we may still infer that there is some evidence that investors are discounting future discoveries of metallurgical coal resources. Notwithstanding the fact that it has been increased, however, the size of the population of metallurgical coal explorers remains too small for this to be stated with any degree of confidence (ie the correlation is too low to be deemed statistically significant at the 5% level), which is similar to the situation in previous years. In addition, it is, to all intents and purposes, impossible to determine whether any relationship is inverted or linear.

Exhibit 126: Graph of resource size (t) vs resource multiple (US$/t) for metallurgical coal explorers



Source: Edison Investment Research

Metallurgical coal multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots EVs of the companies in each subsector against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. In the case of the metallurgical coal subsector, the formula for the best-fit line (in millions) derived via such an analysis is as follows:

EV = 49.7 + (0.048 × inferred tonnes) - (0.128 × indicated tonnes) + (0.105 × measured tonnes)

With the notable proviso that the above analysis includes a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. In general, this could probably not be said to be true. Nevertheless, the results probably do support the obvious conclusion of our in-situ analysis, above, that the best way for metallurgical coal explorers to add value to their resources at the current time is by increasing resources in the measured category.

A summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above is as follows:

Exhibit 127: Metallurgical coal explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	49.66991404	33.48974739	1.483137913	0.276276787	-94.42484	193.7647
Inferred	0.047950207	0.214371456	0.223678134	0.84377763	-0.874416	0.970316
Indicated	-0.127620928	0.365987493	-0.348702975	0.760599784	-1.702338	1.447096
Measured	0.105361121	0.246433123	0.427544478	0.710615745	-0.954955	1.165677

Source: Edison Investment Research

In the case of this analysis specifically, while it is noticeable that there is a fair degree of doubt regarding the values of the factors relating to measured, indicated and inferred resources, there is a moderate level of confidence (albeit still materially below the 95% threshold – as evidenced by its relatively large t-stat values and relatively small associated P-values) attached to the factor relating to the 'intercept'.

Thermal coal

Our analysis of thermal coal explorers was complicated by the fact that there were neither companies with inferred resources only nor indicated & inferred resources only in the population as a whole. In the past, thermal coal resources have never really yielded themselves to a differentiated analysis and have never been presented in this way. In this case, however, the absence of companies in the inferred only and indicated & inferred only categories required us to make assumptions based on a 'logical' relationship between the valuations across the different categories. Inevitably, therefore, we made assumptions that reflected the thesis behind the differentiated analysis – ie that the value of measured resources should be greater than that for indicated resources which, in turn, should be greater than that for inferred resources. These are reproduced below, albeit with the caveat that they necessarily reflect the thinking and approach behind the analysis, rather than the outputs from it (note: see Multiple regression analysis section, below, for an alternative approach and conclusion). Nevertheless, direct comparison may still be made between the results for 'total' resource valuations:

Exhibit 128: Global average in-situ value of explorers' thermal coal resources (US$/t)

	August 2018				August 2017	August 2016	June 2015	August 2014
	Measured	Indicated	Inferred	Total				
In-situ thermal coal value (US$/t)	0.038	0.030	0.015	0.030	0.017	0.013	0.020	0.007

Source: Edison Investment Research, Thomson Reuters Datastream

In the case of thermal coal resources, it is apparent that the 12 months between August 2017 and August 2018 were characterised by a continued recovery in both prices and the in-situ value of resources, with the latter demonstrating a leveraged relationship to the former, such that the percentage of spot price represented by the value of resources also increased:

Exhibit 129: In-situ value of thermal coal resources and spot price of thermal coal (US$ per total tonne), 2014–18

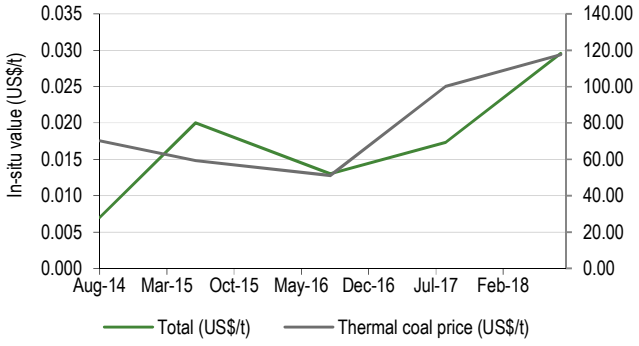
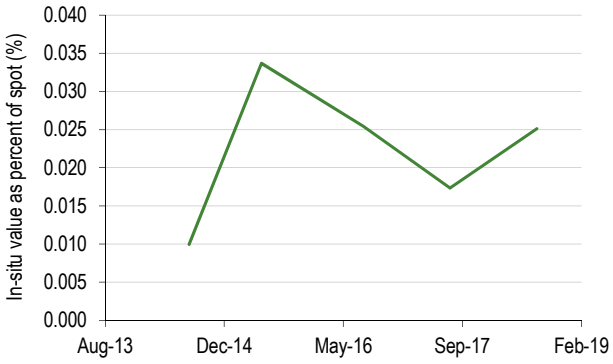


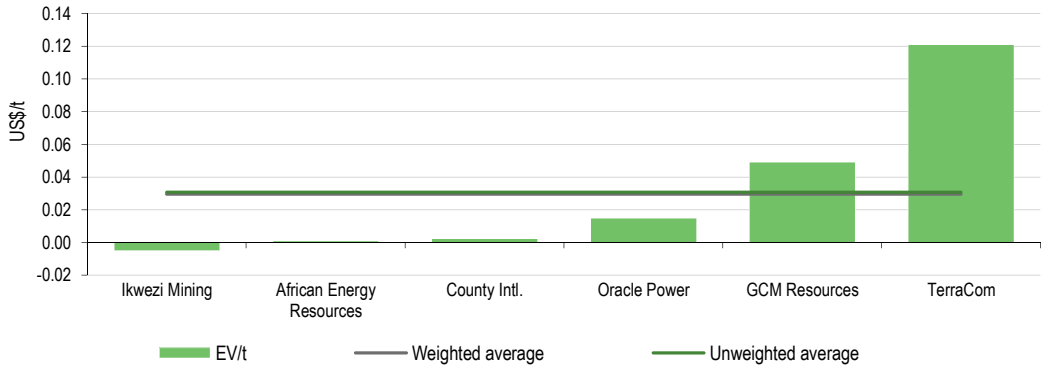
Exhibit 130: In-situ value of thermal coal resources as percentage of spot price of thermal coal (%), 2014–18



Source: Edison Investment Research. Note: Historic thermal coal prices (slightly) restated to reflect single standardised contract.

In addition, there was a much lower standard deviation relating to the results of the companies in the subsector on an undifferentiated basis (ie all resource categories treated equally) than that in the measured category for the same companies when valued on a differentiated basis (ie with their indicated and inferred resources taking the valuations shown in Exhibit 128) – arguing in favour of looking at the subsector on the basis of total resources, rather than resources differentiated by category. In the case of the undifferentiated analysis, there is also a pleasing convergence of the weighted and unweighted average resource multiples of the population, which confers a degree of confidence in this approach.

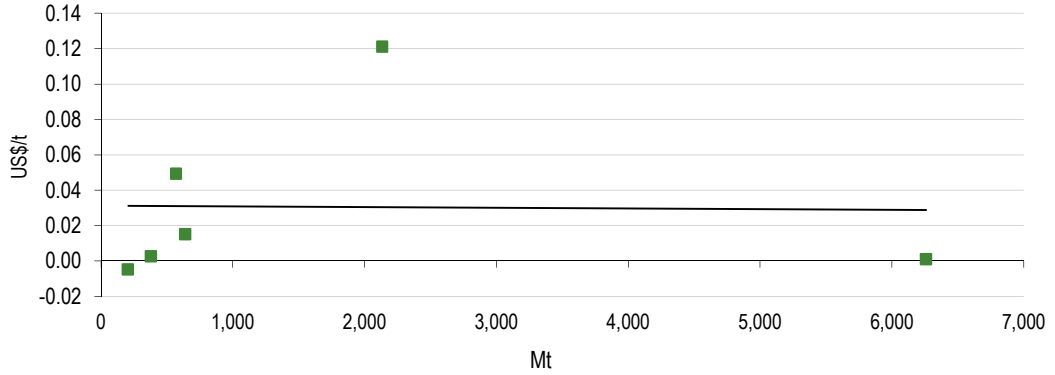
Exhibit 131: In-situ value of explorers' thermal coal resources, by company (US$/t)



Source: Edison Investment Research

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

Exhibit 132: Graph of resource size (t) vs resource multiple (US$/t) for thermal coal explorers



Source: Edison Investment Research

Thermal coal multiple regression analysis

For the first time, in this year's report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the report and their resources, broken down by category. In simple terms, the analysis asserts that a company's EV should be a function of its measured, indicated and inferred resources. The multiple regression analysis therefore plots EVs of the companies in each subsector against their measured, indicated and inferred resources (effectively in four dimensions) and then calculates the best-fit line between the points. In the case of the thermal coal subsector, the formula for the best-fit line (in millions) derived via such an analysis is as follows:

EV = 46.8 + (0.12 × inferred tonnes) − (0.14 × indicated tonnes) − (0.09 × measured tonnes)

With the notable proviso that the above analysis includes a constant (the first argument in the equation), in an ideal world, the factors applied to each of the resource categories would/should be comparable to those calculated in our in-situ analysis, above. In general, this could not be said to be true.

A summary of the statistical outputs of the multiple regression analysis relating to the degree of confidence attached to each of the factors in the equation above is as follows:

Exhibit 133: Thermal coal explorers' multiple regression analysis, t-stats results

	Coefficient	Standard error	t-stat	P-value	Lower 95%	Upper 95%
Intercept	46.77201556	38.5877826	1.212093891	0.349236223	-119.2578126	212.8018
Inferred	0.122481997	0.046788561	2.617776539	0.120180926	-0.078832932	0.323797
Indicated	-0.137363243	0.157707496	-0.871000092	0.475590446	-0.81592383	0.541197
Measured	-0.094605279	0.200333313	-0.472239376	0.683268334	-0.956569955	0.767359

Source: Edison Investment Research

In the case of this analysis specifically, while it is noticeable that there is a modest degree of confidence surrounding the value of the factor relating to inferred resources (as evidenced by its relatively large t-stat values and relatively small associated P-values), this declines regarding the confidence in the value of the 'intercept' and then falls further for the factors relating to measured and indicated resources. In contrast to our in-situ analysis (with all of its caveats) above, this multiple regression analysis therefore suggests that the best way for thermal coal explorers to increase their valuations is by increasing resources in the inferred category, but not then subsequently upgrading them to indicated or measured status.

Bauxite

As with thermal coal, in the past bauxite resources have never readily yielded themselves to a differentiated analysis and have never been presented in this way. In this case, the population of bauxite explorers did not include any with indicated & inferred resources only. As such, we estimated a value for indicated resources that was based on a point halfway between its logical maximum level (equivalent to that of measured resources) and its logical minimum (equivalent to that of inferred resources). Unlike thermal coal, however, under almost any set of assumptions, the value for indicated resources would fall between those of measured and inferred resources and so, in this instance, it may be that the valuations of bauxite juniors' are reverting to a 'logical' relationship with respect to the categorisation of their resources and that a differentiated approach is therefore appropriate.

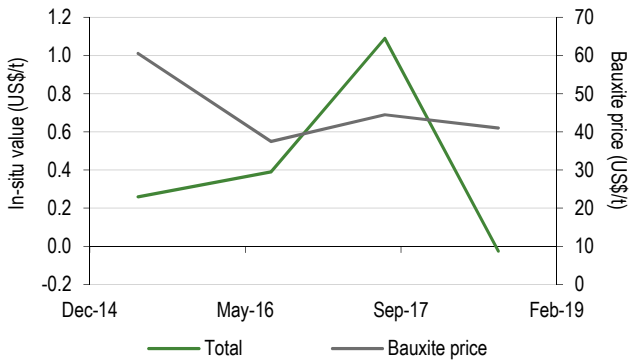
Exhibit 134: Global average in-situ value of explorers' bauxite resources (US$/t Al_2O_3)

	August 2018				August 2017	August 2016	June 2015
	Measured	Indicated	Inferred	Total			
In-situ bauxite value (US$/t)	6.47	1.80	(0.26)	(0.03)	1.09	0.39	0.26

Source: Edison Investment Research, Thomson Reuters Datastream

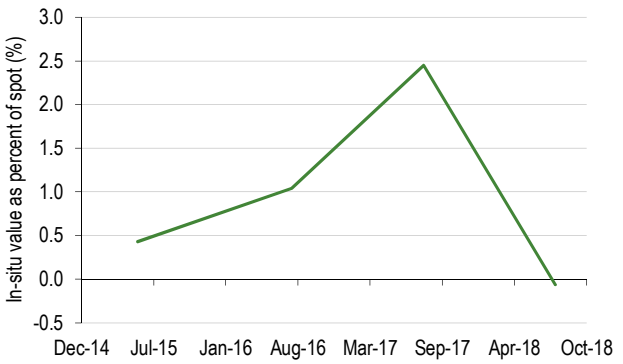
Whether this is proven to be true into the future is, at the current time, a matter of conjecture. More striking, however, is the sharp decline in the total resource rating between 2017 and 2018, at a time when the bauxite price has declined only modestly (-7.9%):

Exhibit 135: In-situ value of bauxite resources (US$/t Al_2O_3) and spot price of bauxite (US$/t), 2015–18



Source: Edison Investment Research. Note: Historic bauxite price restated to reflect single contract.

Exhibit 136: In-situ value of bauxite resources as percentage of spot price of bauxite (%), 2015–18

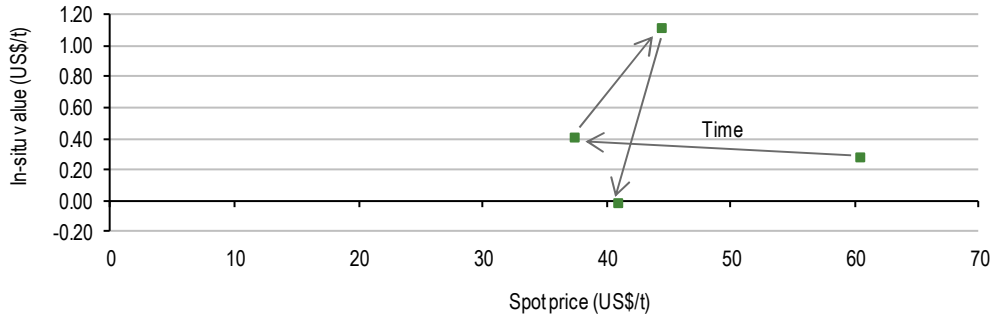


Source: Edison Investment Research. Note: Historic bauxite price restated to reflect single contract.

Two immediate explanations could be advanced for this:

- That bauxite resources were relatively overvalued in 2017, in anticipation of a further increase in the bauxite price; when the bauxite price then fell in 2018, there was a disproportionate fall in the value of bauxite resources (see Exhibit 137, below).
- Bauxite resources are reverting to a valuation, within the universe of mining resources, more in keeping with the price of bauxite itself (see Exhibit 139 on page 67).

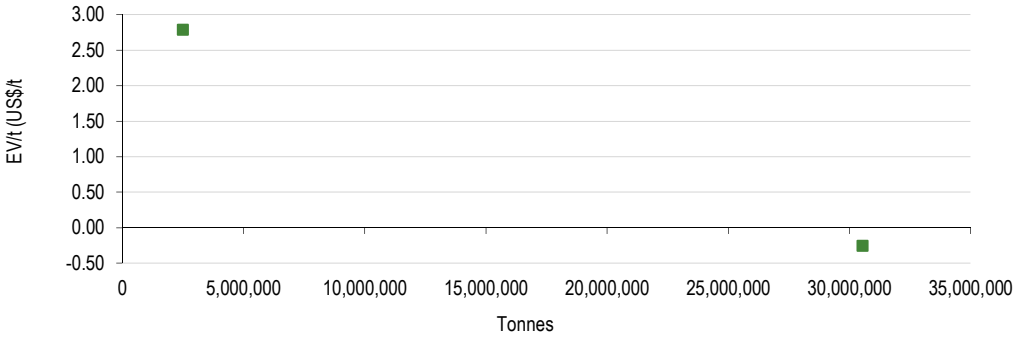
Exhibit 137: In-situ value of bauxite resources (US$/t Al_2O_3) vs spot price of bauxite (US$/t), 2015–18 (US$/t)



Source: Edison Investment Research. Note: Historic bauxite price restated to reflect single contract.

As in 2017, while anecdotally 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.

Exhibit 138: Graph of resource size (t Al_2O_3) vs resource multiple (US$/t Al_2O_3) for bauxite explorers



Source: Edison Investment Research

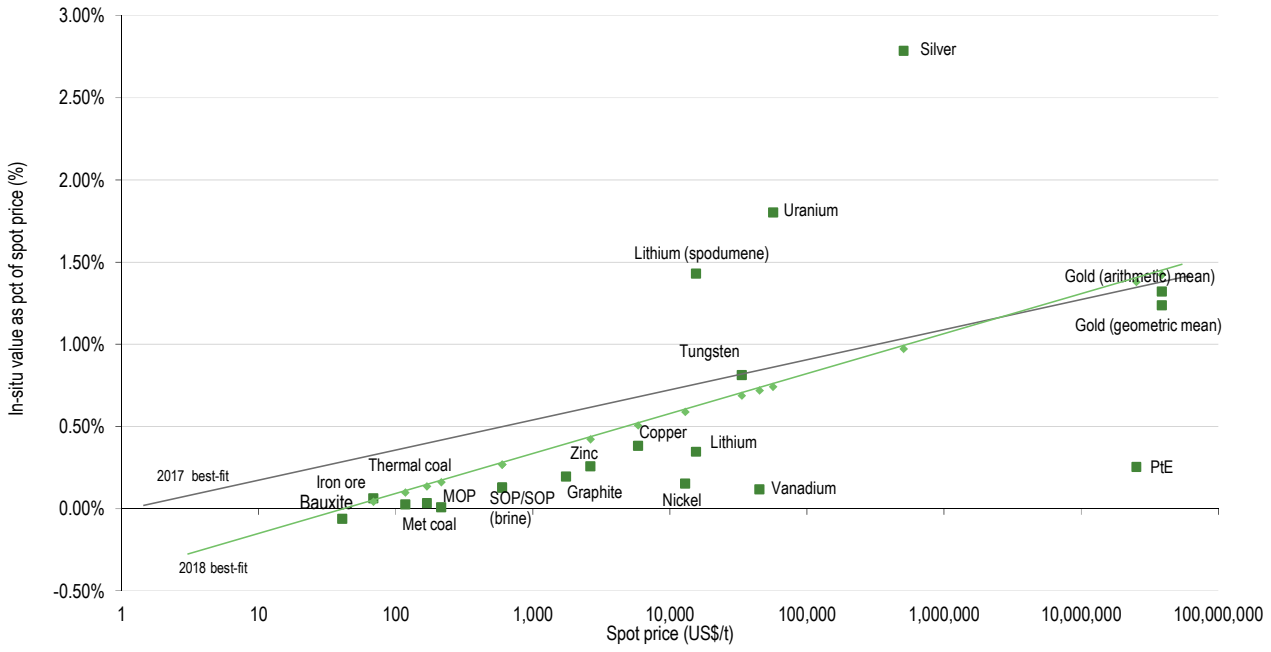
Bauxite multiple regression analysis

Although a multiple regression analysis was performed for bauxite explorers by Edison in 2018, unfortunately the population size of the subsector was too small to render the results meaningful, with the possible exception of the merest hint that adding inferred resources may indeed be value destroying to junior exploration companies at the current time (supporting the findings of our in-situ analysis, above).

Undifferentiated analysis

In addition to our differentiated analysis, we have 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$14.95/oz (vs US$17.54/oz in 2017 and US$16.84/oz in 2016), which equated to 1.24% 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 1.24% 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 so that they may be shown on the same scale (for example, gold at the time was US$1,208/oz, or US$38,838,408/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 139: In-situ resource values vs spot prices, selected metals and minerals



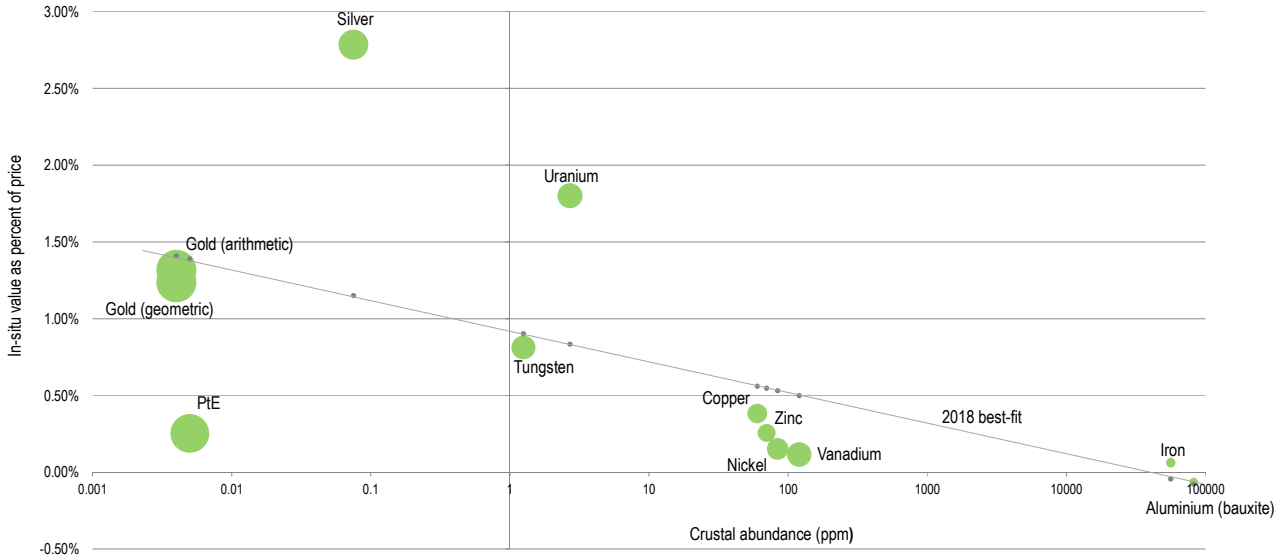
Source: Edison Investment Research

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, although note that there is no statistically significant correlation between prices themselves 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.
- Only four metals and minerals have in-situ values 'above trend' given their spot prices; of these one might be regarded as relatively 'new' in terms of its existence on publicly traded stock markets – namely lithium (spodumene). The traditional three are silver, uranium and tungsten (elevated from 'below trend' in 2017).
- The (geometric) best fit line of the points in 2018 is steeper lying than the equivalent line in 2017, such that companies with deposits of metals or minerals with a spot price of US$46.41/t or less should not expect to be afforded any in-situ value for their resources. Much of the steepening can be attributed to the moves in in-situ value for the bauxite and vanadium sub-sectors relative to moves in their product prices. Note however that the line, while different to last year, reasonably closely approximates that of 2016.

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

Exhibit 140: In-situ resource values (% of spot) vs crustal abundance (ppm), selected metals and minerals

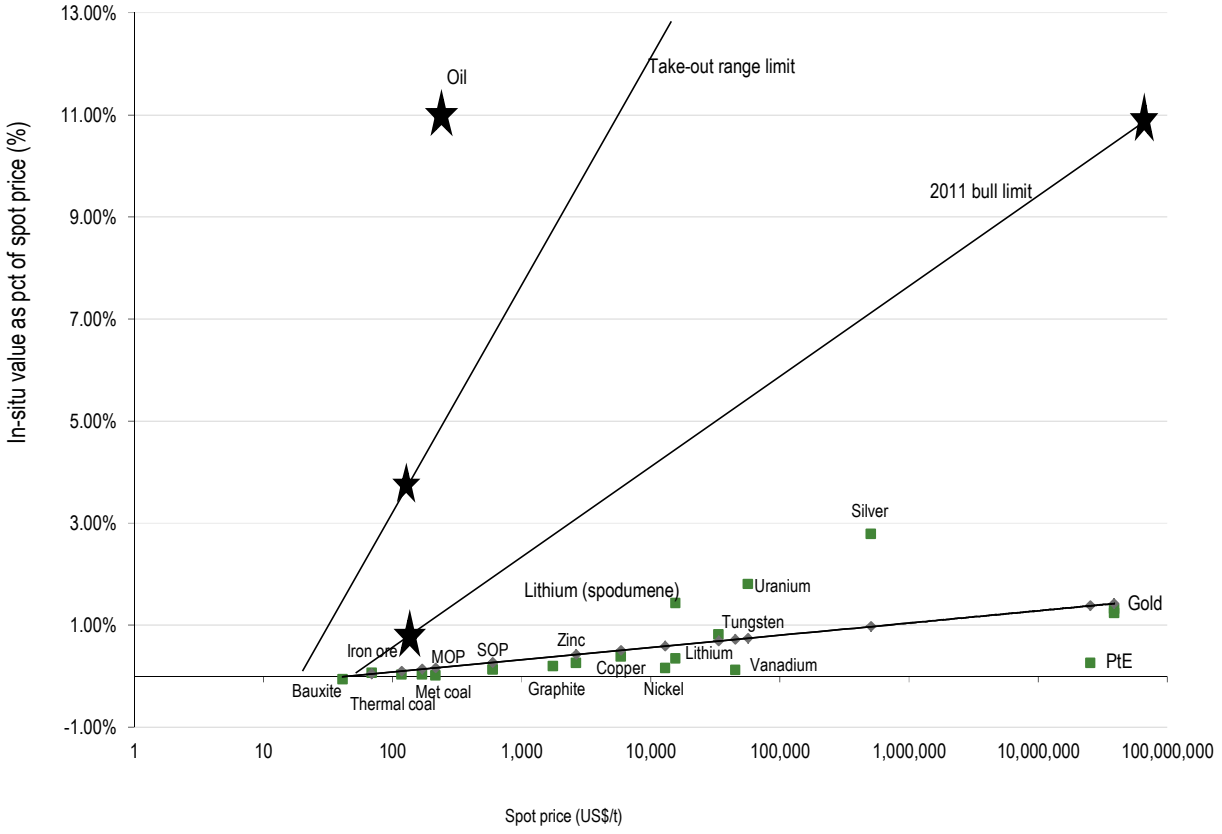


Source: Edison Investment Research. Note: Bubble size represents Log (price US$/t).

Note that the best-fit line in 2018 is markedly steeper than the equivalent in 2017 (and approximating the best-fit line in 2016), reflecting not least the decline in the value of bauxite resources, from in excess of 2% of the spot price of bauxite to below zero (see pages 65–66), in the period under review.

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 141: In-situ resource values (as percentage of the spot price) vs spot prices (US$/t), within historical context, selected metals and minerals



Source: Edison Investment Research

Aside from the lower limit line of best fit (which is identical to that shown in Exhibit 139), two additional lines are shown. They represent 1) the estimated position of the line of best fit at the top of the bull market in 2011, and 2) 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 139.

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 our oil & gas team and is based on an oil price of US$330/t (US$45/bbl) and typical in-ground valuations (IGVs) of US$5/bbl. Comparing the oil industry and the mining industry, 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.

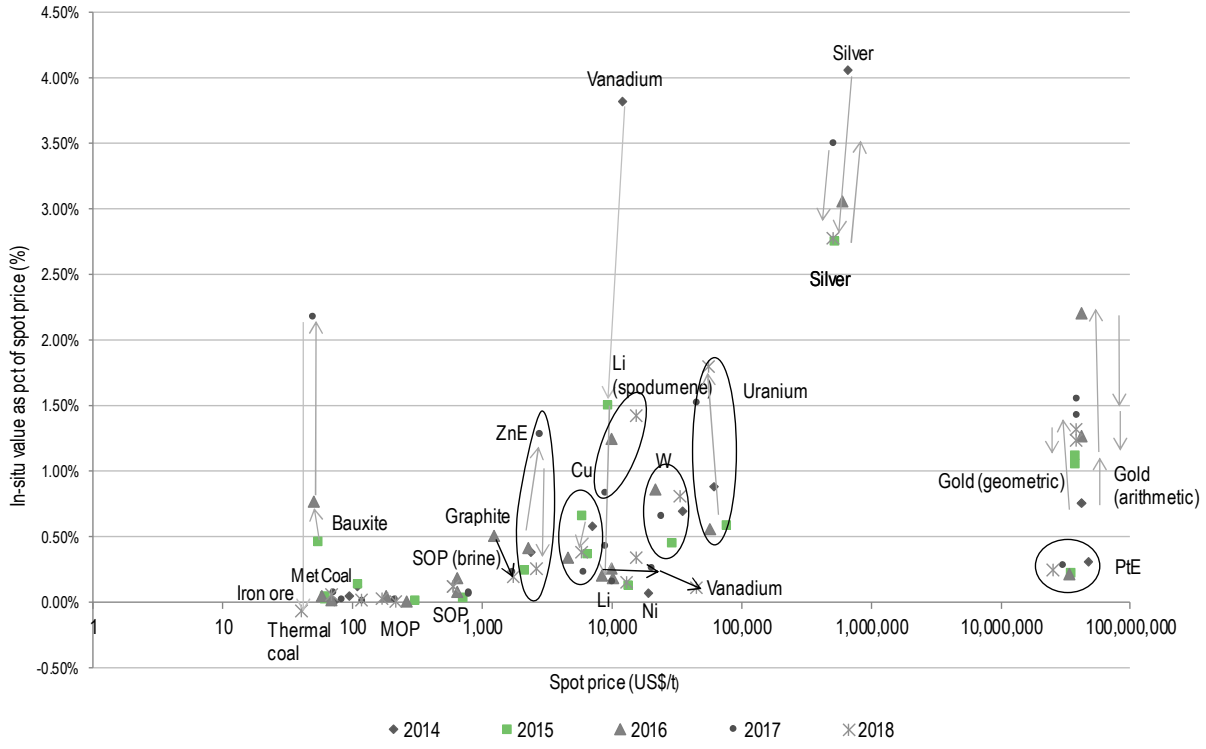
Of the 17 distinct metals and minerals profiled, the prices of eight (gold, copper, silver, platinum, zinc, SOP, iron ore and bauxite) declined since our last note on the subject (Mining overview: Unlocking the price to NPV discount, published in November 2017). In the same time frame, the prices of six (vanadium, tungsten, uranium, nickel, lithium and thermal coal) have risen, while three (graphite, MOP and metallurgical coal) have remained ostensibly unchanged.

Similarly, the in-situ values of eight metals and minerals (namely gold, platinum, silver, zinc, graphite, MOP, iron ore and bauxite) have declined between August 2017 and 2018, while the in-situ values of 10 (uranium, copper, nickel, thermal coal, metallurgical coal, SOP, brine, tungsten,

lithium and spodumene lithium) have all increased and one (vanadium) has remained ostensibly unchanged. However, not all of the metals and minerals that saw price increases also saw in-situ values increase and vice versa. Notable exceptions were:

- In-situ value declined, despite flat/rising prices: graphite.
- In-situ value flat, despite strongly rising prices: vanadium.
- In-situ value increased, despite prices falling: copper, SOP, metallurgical coal and thermal coal.

Exhibit 142: In-situ resource values vs spot prices, selected metals and minerals, 2014–18



Source: Edison Investment Research

Several aspects of the graph are noteworthy:

- The sharp decreases in in-situ value as a percentage of spot price of bauxite and zinc (at least reversing the gains of the previous year).
- The moderation in the in-situ value of silver resources as a percentage of spot price, but its continued premium valuation within the universe of mining assets.
- The decrease in the in-situ value of vanadium (expressed as a percentage of spot) despite a very strong bull market in the price of vanadium (in the form of vanadium pentoxide, V_2O_5) – suggesting that either vanadium assets listed in global equity markets are very cheap relative to those of other metals with comparable prices or that the equity markets are anticipating a fairly material future decline in the price of vanadium.
- The relatively high in-situ value of uranium resources being maintained for a second year in succession (this time coincident with a recovery in the price of uranium).

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

Exhibit 143: In-situ resource valuation characteristics, by metal/mineral

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

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

In summary:

- The majority of metals and minerals now demonstrate some form of discounting of future discoveries, with the single exception of uranium at the current time (although it has exhibited this characteristic strongly at various times in the past).
- No metals exhibit a positive correlation between resource size and in-situ valuation (cf two, namely zinc and ASX gold, in 2017).
- Eight metals and minerals exhibit a measured resource discount, indicating that investment with the intention of promoting indicated resources to the measured category is likely to be value destroying.

NonSuch Gold

The physical limitations created by financial boundaries

In the report Gold: New benchmarks for old, published in November 2012, we created a notional mining company, which we called NonSuch Gold Ltd. The characteristics of this company were designed to approximate those to which many junior gold mining companies aspire and we were then able to use the in-situ resource valuations calculated earlier in this report in conjunction with our 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 interrogate that valuation with respect to both outside influences and internal development strategies.

Creating, valuing and manipulating NonSuch Gold

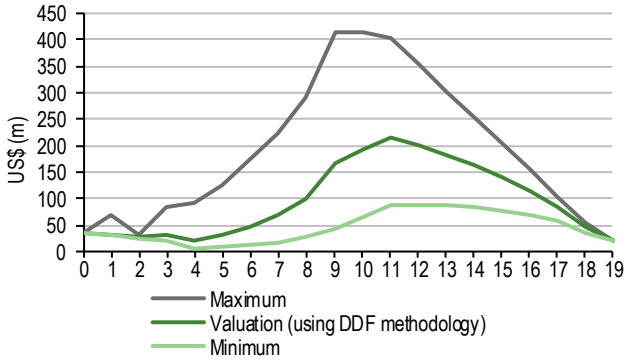
The characteristics of NonSuch Gold are designed to approximate those to which many junior gold mining companies aspire, namely:

- The delineation of a 1.6Moz resource, 63.4% of which (being the measured and indicated portion of the resources) is then converted into reserves and mined at a rate of 100koz per year for 10 years. The company is deemed to be listed in London and it will be 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 delineates an inferred resource in year 1, an indicated and inferred resource in year 2 (in a 48.9:51.1 ratio) and a measured, indicated and inferred resource in year 3 (in a 19.6:43.8:36.5 measured:indicated:inferred ratio). It then raises 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 completes a final round of equity, in addition to debt, funding, such that its leverage (debt/(debt+equity)) peaks at 50%, and embarks on the first of three years of capital expenditure. Production ramp-up begins in year 8 and full production is achieved in year 9. Full production is then maintained from years 9 to 18 inclusive (ie 10 years). Working capital is released in year 19 when the company reverts to being an exploration entity (its only assets being cash and an inferred resource).
- In years 0 to 3, the company is 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 26 on page 21. 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 our 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 1.6Moz 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.

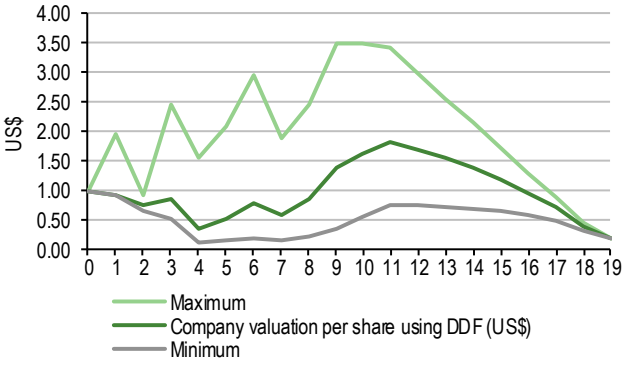
On the basis of the assumptions set out above, the undiscounted value of the dividends paid out to shareholders is US$408.2m, comprising cash flow from operations (US$459.4m), minus total life-of-mine capex (US$124.3m), plus total equity funding (US$90.3m) minus terminal cash balances (US$17.2m). Graphs 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 144: NonSuch Gold value by year



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

Exhibit 145: NonSuch Gold share price by year



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

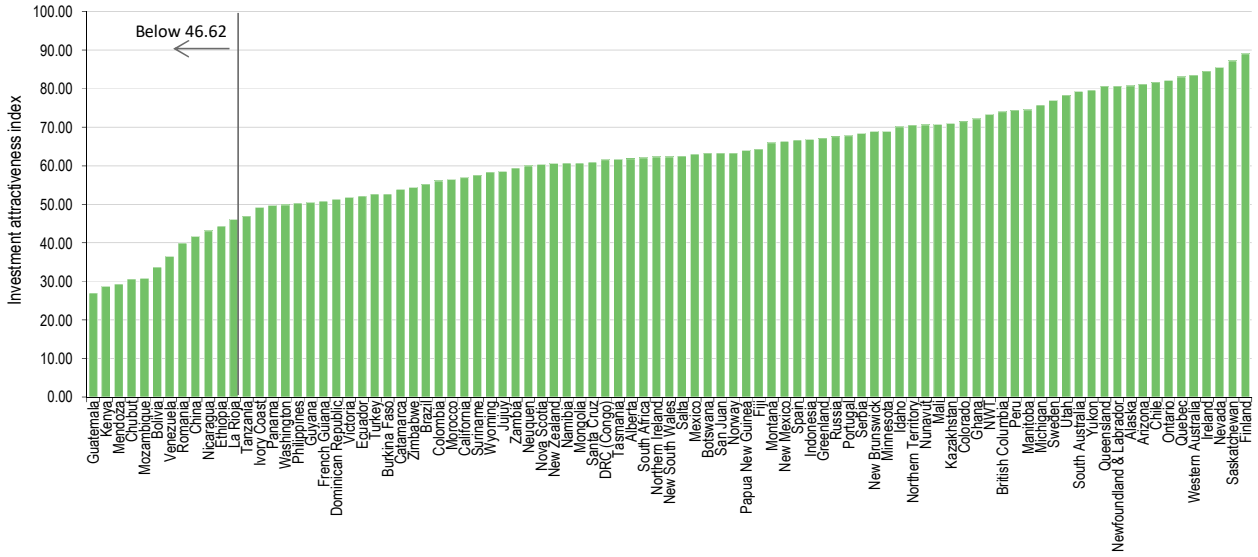
Of note is the spike in maximum potential valuation in year 1 – although note that it is much less pronounced than the equivalent analysis in 2017. This is also a feature of the Australian and Canadian markets, although the spike in maximum potential Canadian market valuations tends to occur in year 3, rather than year 1. Nevertheless, it is an indication of the significant valuation premia that 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 the 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 44.9% discount rate (cf 40.3% previously) is applied to future dividends (or cash flows), within a range from 8.0% to 62.0% (see Gold: US$2070 by 2020, published in November 2013).

If political risk is deemed to be measured by the Fraser Institute's Investment Attractiveness Index and the lowest-risk mining investment destination (Finland in 2017, with a score of 89.04) is assumed to correspond to a minimum discount rate of 8.0% and the highest-risk mining investment destination (Guatemala, with a score of 26.96) is assumed to correspond to a maximum discount

rate of 62.0%, then a discount rate of 44.9%, as applied to potential future dividends, occurs at a Fraser index score of 46.62 – between La Rioja (Argentina) and Tanzania:

Exhibit 146: Fraser Institute Investment Attractiveness Index, 2017 survey



Source: Fraser Institute, Edison Investment Research

On this basis, some 12 jurisdictions appear below the implied investible cut-off line for 'average' projects (cf 29 previously).

EV/NPV: A key transition

For only the second time in this series of reports, we have performed a price to project NPV analysis for those companies for which data exists. The analysis covers 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, we formed a view as to what an 'average' (or mean) project looks like but, significantly, were able to conclude that, owing to the skewed distribution of valuations relative to project economics, statistical means (as opposed to modes) are of very little use in predicting company valuations in the real world. Moreover, we observed that it is not always the case that companies with high IRRs also have 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 adding to a company's value. 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 147: Price: NPV analysis sample size, by commodity

	2018		2017	
Commodity	Number of companies	Percentage of total (%)	Number of companies	Percentage of total (%)
Gold	34	33	33	52
Uranium	14	14	14	22
Copper	10	10	8	13
Silver	11	11	7	11
Zinc	4	4	1	2
MOP	3	3		
Graphite	11	11		
PGM	2	2		
Nickel	4	4		
Iron ore	4	4		
Met coal	2	2		
SOP (brine)	2	2		
SOP	1	1		
Total	**102**	**100**	**63**	**100**

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

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 the discount rates used. Where possible, we have attempted to source data to make comparisons as direct as possible. For the gold subsector 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%. Prices for other subsectors were similarly grouped, although no attempt was made to make the price at which, for example, the copper subsectors studies were conducted directly comparable to gold studies at US$1,250/oz. Inevitably, there were exceptions, although we observed that these tended not to be outliers in terms of either their NPVs or their IRRs. Where appropriate, these have been highlighted.

Sample notes

Of the 102 companies for which project data was collated, a small number had more than one project in development. In this case, attributable project NPVs were aggregated and IRRs were derived by a weighted average of the individual projects' IRRs, according to NPV attributable to the parent. Within this context, the range of project NPVs and IRRs within the sample (which was significantly larger than in 2017) was as follows:

Exhibit 148: Project NPV and IRR sample, range and averages

	2018		2017	
	IRRs (%)	NPVs (US$m)	IRRs (%)	NPVs (US$m)
Maximum	200.0	7,000.0	404.0	4,800.0
Mean	**40.1**	**648.8**	**43.2**	**433.1**
Minimum	1.0	-552.0	1.0	-552.0

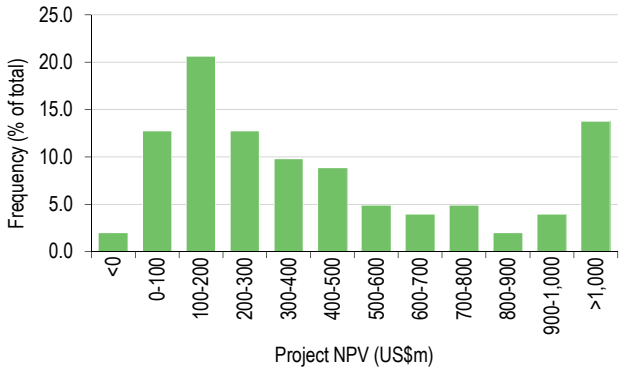
Source: Edison Investment Research, company sources

On first impression, therefore, the average project has an NPV of US$648.8m (cf US$433.1m in 2017) and an IRR of 40.1% (vs 43.2%). While Edison has not performed an analysis to determine the reason for the increase in project NPV in particular, anecdotally, we believe that it is the result of the inclusion of more bulk mineral projects (eg MOP, metallurgical coal and iron ore) into the sample. However, even a brief comparison of the position of the mean with respect to both the maximum and minimum 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

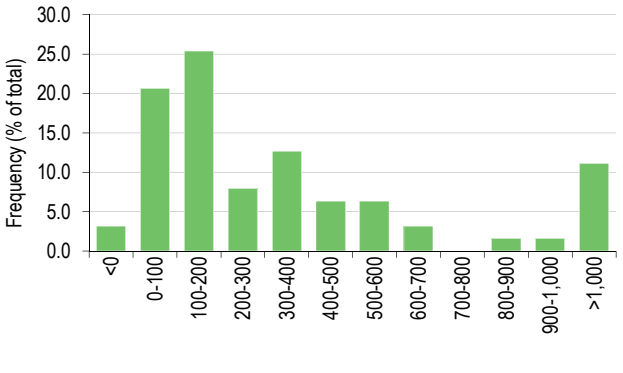
A histogram of the frequency of project NPVs, broken down into US$100m increments, by number and by percentage of the total, is as follows:

Exhibit 149: Histogram of companies' aggregate project NPVs (US$m), percentage of the total, 2018



Source: Edison Investment Research, company sources

Exhibit 150: Histogram of companies' aggregate project NPVs (US$m), percentage of the total, 2017



Source: Edison Investment Research, company sources

Note that, as the sample size of our study has increased, so the distribution of NPVs has tended towards something approaching a log normal one. Readers' attention is drawn to the disproportionate sizes of the interval to the extreme right (>1,000) of the histogram and also the seeming shift in skew of the distribution towards the right since 2017.

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

- A single population with a unimodal distribution, skewed right.

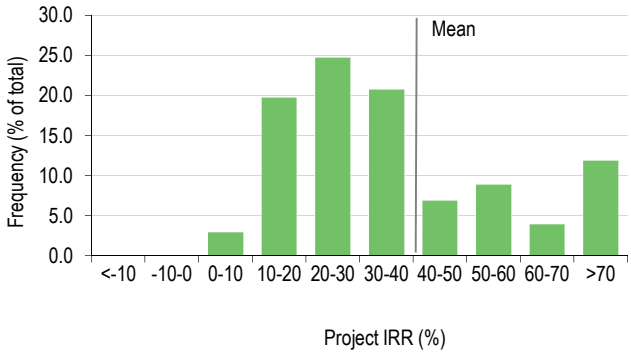
- Two populations (one of smaller projects with a mode in the US$100–200m interval and one of larger projects with a mode in the US$900–1,000m interval), giving a bimodal distribution, skewed right.

Note that the additional tri-modal distribution, upon which we speculated in 2017, now seems increasingly unlikely in the light of 2018's data.

Sample IRRs

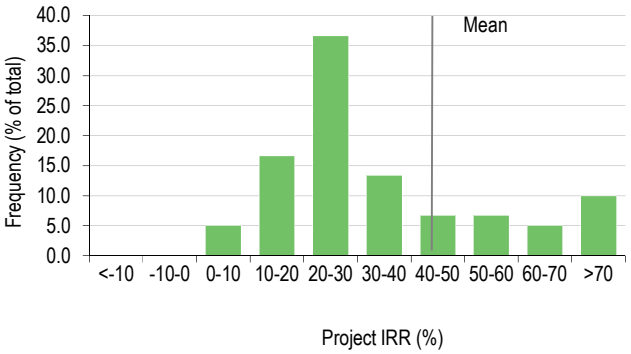
While the distribution of NPVs appears to have standardised over the course of the last year, ironically the distribution of IRRs appears to have altered to a more equivocal one and become open to a number of interpretations, including the possibility that it might be bi- or tri-modal:

Exhibit 151: Histogram of companies' weighted average project IRRs (%), percentage of the total, 2018



Source: Edison Investment Research, company sources

Exhibit 152: Histogram of companies' weighted average project IRRs (%), percentage of the total, 2017



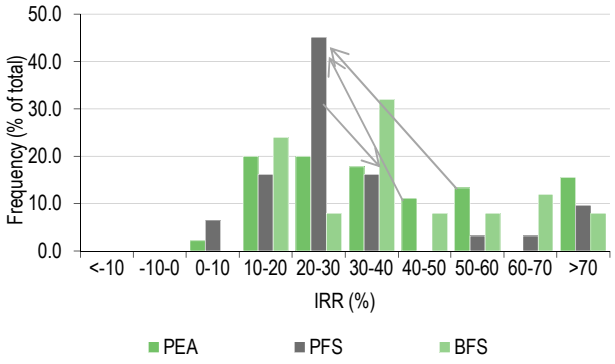
Source: Edison Investment Research, company sources

When considered with reference to the stage of development however (see Exhibits 153 and 154, below), a number of differences compared with our analysis in 2017 are apparent:

- There are a greater proportion of projects at PEA stage with IRRs in the range 30–40%, acting to standardise the PEA distribution.
- There are more projects at PFS stage with IRRs in the range 30–40%.
- There has been an apparent shift in projects at BFS stage with IRRs in the range 20–30% into the 30–40% range.

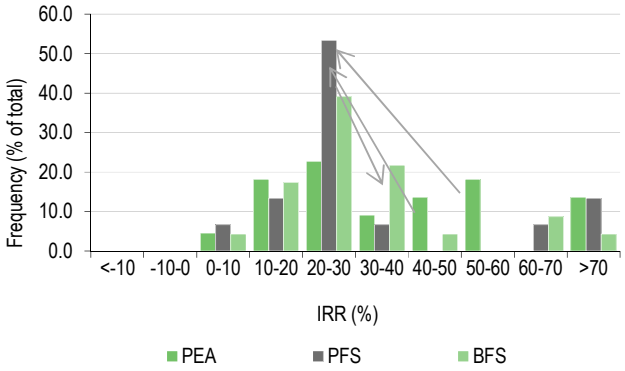
Notwithstanding the above observations however, it is interesting to note that the mean IRR for companies at PEA stage is 41.0%, while it is 38.9% for companies at PFS stage and 39.9% for companies at BFS stage – ie on average, there is very little difference between the means of the IRRs for each type of study concluded.

Exhibit 153: Histogram of companies' average project IRRs, by study type (percentage of the total), 2018



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

Exhibit 154: Histogram of companies' average project IRRs, by study type (percentage of the total), 2017



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

Once again however, in comparing the different distributions, we are probably able to invoke our hypothesis from 2017 that PEA stage projects with IRRs in the range 40–60% evolve into PFSs with IRRs in the range 20–30%, which themselves evolve into BFSs with IRRs in the range 30–40% (as shown by the arrows).

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 153). 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 investors, which results in project IRRs c 10% higher than their equivalent PFS numbers – although some proportion appear to see their IRRs finessed somewhat higher, to in excess of 60%.

By contrast, projects with exceptional IRRs (>70%) at PEA stage appear to see a proportion of these brought back to 50–60% IRRs at either PFS or BFS stages.

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), of which a summary is provided in the table below, comparing 2018 results with 2017 results:

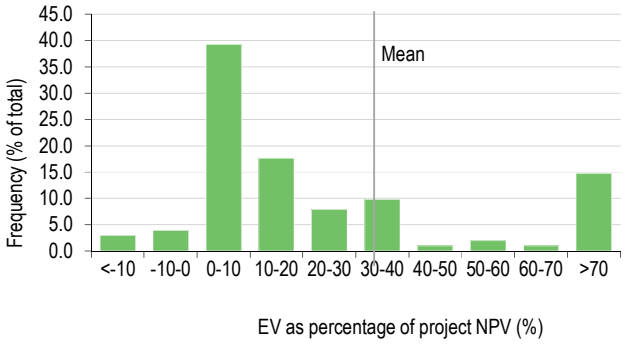
Exhibit 155: Company EV/NPV (%), range and averages, 2018 vs 2017

	2018	2017
Maximum	524.4	-13.4
Mean	33.1	52.4
Minimum	-24.3	428.3

Source: Edison Investment Research

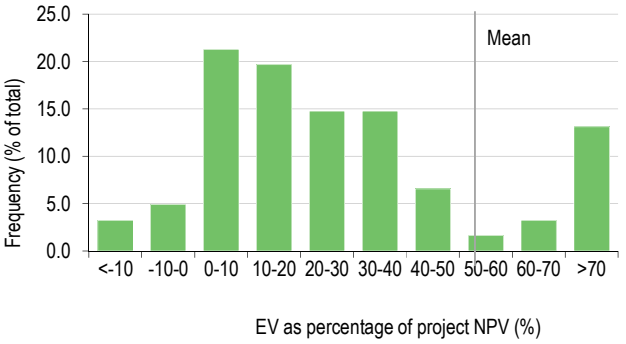
The distributions of these valuations for both 2017 and 2018 are shown below:

Exhibit 156: Company EV expressed as a percentage of attributable project NPV (%), 2018



Source: Edison Investment Research, Thomson Reuters Datastream, company sources. Note: Bar denoting >70 ranges up to 524%.

Exhibit 157: Company EV expressed as a percentage of attributable project NPV (%), 2017



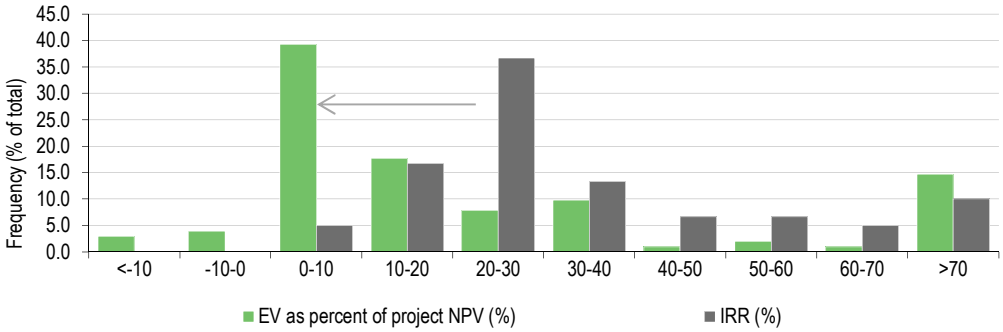
Source: Edison Investment Research, Thomson Reuters Datastream, company sources. Note: Bar denoting >70 ranges up to 428%.

A number of features are immediately apparent:

- The lower mean EV/NPV recorded in 2018 (33.1% vs 52.4%).
- The smaller discrepancy between the mean and the mode of the distribution in 2018 cf 2017.
- The shift in the distribution to the left, with the exception of the right-most bar and the data point at the extreme right of the distribution (524% vs 428%), increasing the skewness of the distribution to the right. Note: this shift also caused the reduction in the mean noted in the prior point.
- While the size of projects has increased between 2017 and 2018 and the size of IRRs has been largely maintained (see Exhibit 148), the valuation of companies relative to the size of their projects has decreased.

At first glance, it is tempting to conclude that companies have an EV/NPV that is 20 percentage points less than the IRRs of their projects, as implied by the graph below:

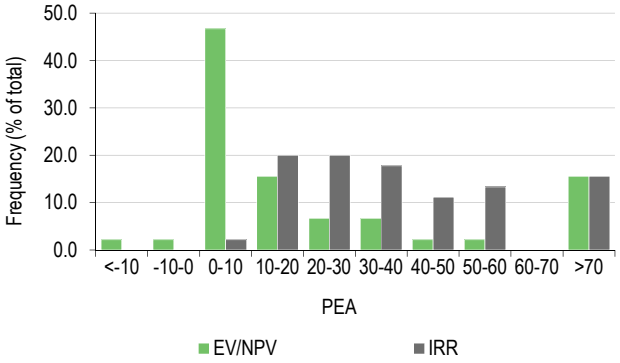
Exhibit 158: Company EV as percentage of attributable NPV (%) and project IRR (%)



Source: Edison Investment Research, Thomson Reuters Datastream, company sources. Note: See text for explanation of arrows; bar denoting >70% ranges up to 524% for EV/NPV and up to 200% for IRR.

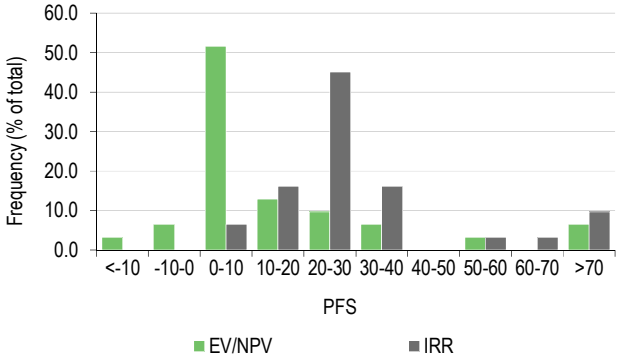
However, this *prima facie* may be honed by considering the stage of development of the projects in question. In particular, the majority (almost) of companies at PEA and PFS stage are valued at an EV/NPV in the range 0–10%, almost regardless of IRR:

Exhibit 159: Company EV as percentage of attributable NPV (%) and project IRR (%), PEA stage



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

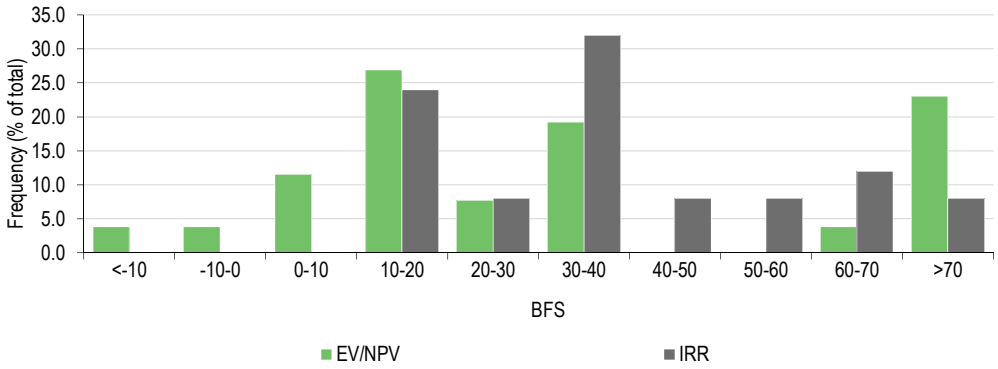
Exhibit 160: Company EV as percentage of attributable NPV (%) and project IRR (%), PFS stage



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

In addition, while there is a better seeming alignment of valuations (as represented by the EV/NPV measure) and IRRs at BFS level, there is still clearly an over-representation of companies with EV/NPVs in the range -10–10% relative to IRRs and an over-representation of IRRs in the 40–60% range relative to NPVs:

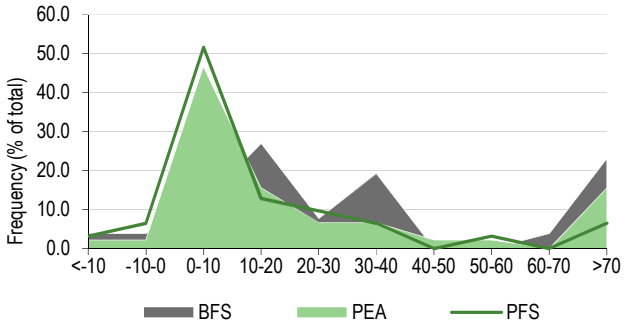
Exhibit 161: Company EV as percentage of attributable NPV (%) and project IRR (%), BFS stage



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

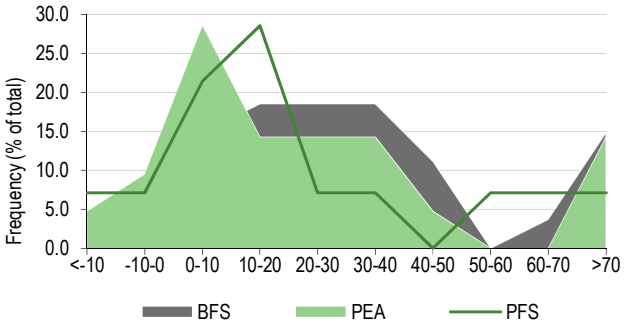
Later analysis will suggest that even these interpretations are somewhat simplistic (see pages 88–95). In the interim, however, it is possible to say, at this stage, that different ranges of valuation are associated with different stages of development. Moreover, when compared with 2017, it can be seen that there has been a distinct shift in the distributions. The probability density distributions relating to PEAs and PFSs in particular appears to have shifted to the left and although the distribution relating to BFSs appears to have remained relatively unchanged (with the notable exception of a dip in companies valued at 20–30% of attributable NPV) there are also now more companies in this category with negative EVs (see below).

Exhibit 162: Company EV as percent of attributable project NPV (%), by study type, probability density distribution, 2018



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

Exhibit 163: Company EV as percent of attributable project NPV (%), by study type, probability density distribution, 2017



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

Once again, readers' attention is drawn to the disproportionate sizes of the intervals at the extreme right (>70%) of the graphs. As in 2017, it is probably a matter of opinion as to whether each curve in the graphs is unimodal or bimodal (suggesting a market distinction between small/averagely rated companies and highly rated ones). Also of note is the absence of company EV/NPVs in the range 40–50% for projects at both PFS and BFS stage of development and the absence of company EV/NPVs in the range 60–70% for companies at PEA stage of development (and PFS, again) – arguably militating in favour of a bimodal distribution. A summary of the data, in tabular form, is as follows:

Exhibit 164: Company EV as percent of attributable project NPV (%), by study type, summary

	2018					2017				
Study type	**Minimum**	**Mode interval**	**Mean**	**Maximum**	**Range**	**Minimum**	**Mode interval**	**Mean**	**Maximum**	**Range**
PEA	-24.3%	0–10%	24.1%	154.2%	178.5%	-13.1%	0–10%	54.0%	427.1%	440.2%
PFS	-15.4%	0–10%	18.2%	202.9%	218.3%	-13.4%	10–20%	25.4%	134.8%	148.2%
BFS	-10.1%	10–20%	66.5%	524.4%	534.5%	2.6%	10–40%	66.6%	428.3%	425.7%
All studies	**-24.3%**	**0–10%**	**33.1%**	**524.4%**	**548.7%**	**-13.4%**	**0–10%**	**52.4%**	**428.3%**	**441.7%**

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

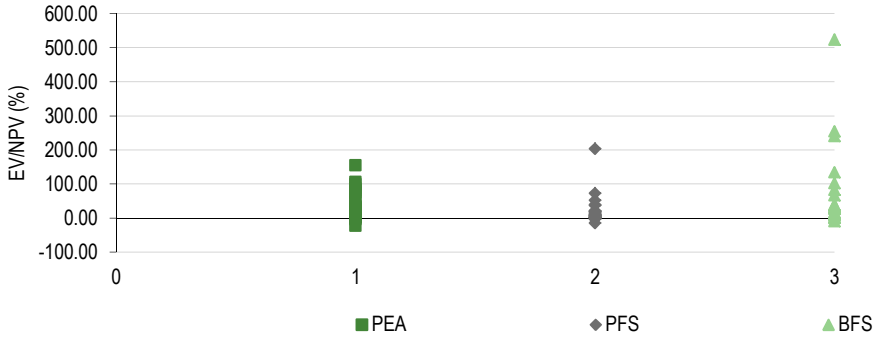
Since 2017 then, a number of observations can be made:

- Minimum valuations across all three types of study have become more negative.
- Mean valuations across all three types of study have reduced.
- The mean valuation for companies with projects at PEA stage, in particular, has reduced materially.
- With the exception of the curve describing PFS valuations, the mean of the curves describing companies with PEA and BFS level studies are more than one modal interval away from those modes.
- The mean valuation of companies with projects at PFS stage of development remains below that of companies with projects at PEA stage (which is counter-intuitive).

The fourth point, in particular, is significant, as it renders the use of the mean as a tool for predicting company valuations of questionable value.

The same data may also be depicted as follows:

Exhibit 165: Company EV as percent of attributable project NPV (%), by study type



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

One method to remedy the discrepancy between the mean and mode caused by the skewness of the distributions is to exclude outliers from the samples. In this case, we have chosen to define an outlier as any company with an EV/NPV valuation that is more than one standard deviation away from the mean, in which case the equivalent summary of the three distributions is as follows for ordinarily valued companies:

Exhibit 166: Company EV as percent of attributable project NPV (%), by study type, ordinarily valued companies, excluding statistical outliers

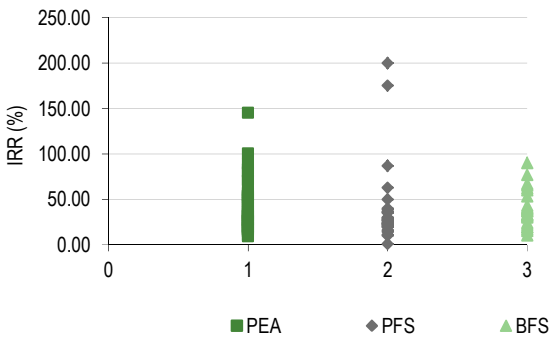
	2018					2017				
Study type	Minimum valuation	Distribution mode	Mean valuation	Maximum valuation	Range	Minimum valuation	Distribution mode	Mean valuation	Maximum valuation	Range
PEA	-4.8%	0–10%	11.7%	50.7%	55.5%	-13.1%	0–10%	18.9%	90.0%	103.1%
PFS	-15.4%	0–10%	9.9%	51.3%	66.7%	-3.7%	10–20%	16.3%	52.6%	56.3%
BFS	-10.1%	10–20%	30.9%	133.5%	143.6%	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:

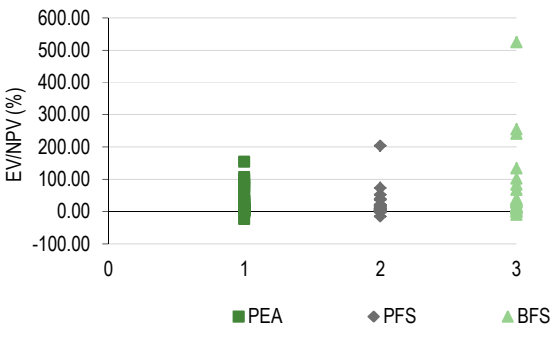
- The much closer alignment of the mean and the mode.
- The apparent 'anomaly', whereby the mean is lower for PFS compared with PEA level projects nevertheless remains. On the one hand this inclines us to believe that this may be a persistent feature of mining company valuations in general, although it may also 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 167: Project IRRs, by study type (%), 2018



Source: Edison Investment Research, company sources

Exhibit 168: Company EV as percent of attributable project NPV (%), by study type, 2018



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

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

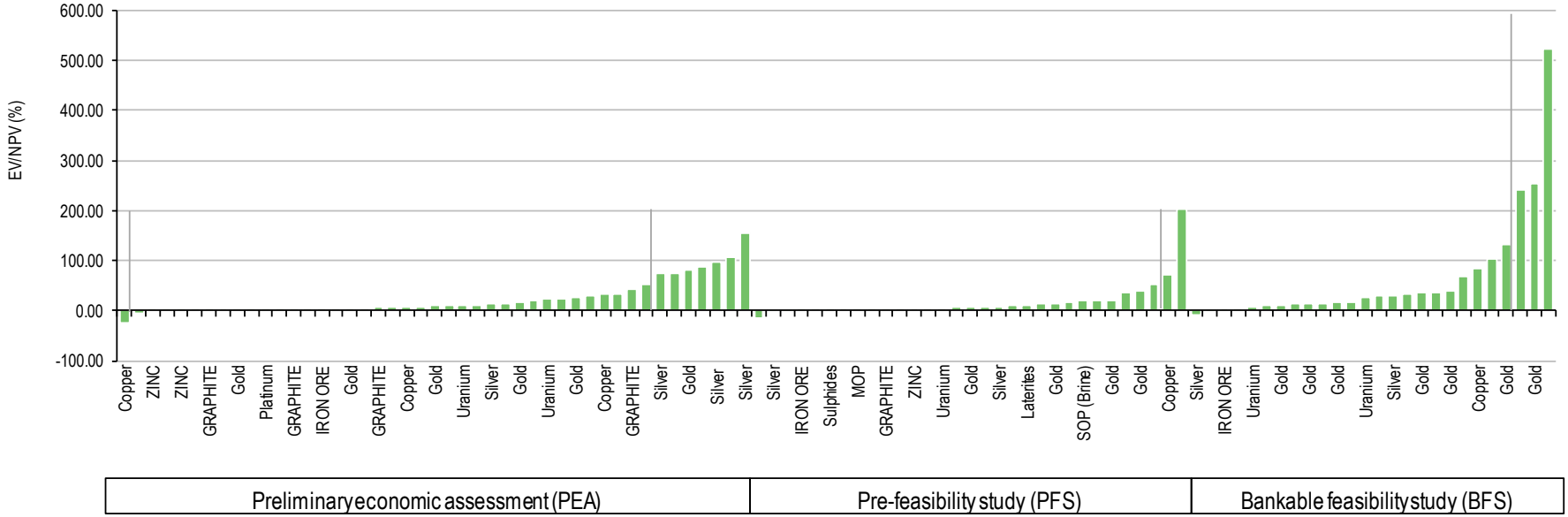
Exhibit 169: Company EV as percent of attributable project NPV (%), by study type, exceptionally valued companies

	2018					2017				
Study type	Minimum valuation	Distribution mode	Mean valuation	Maximum valuation	Range	Minimum valuation	Distribution mode	Mean valuation	Maximum valuation	Range
PEA	59.1%	N/A	96.5%	154.2%	95.1%	167.5%	N/A	276.3%	427.1%	259.6%
PFS	56.0%	N/A	137.6%	202.9%	146.9%	64.8%	N/A	99.8%	134.8%	70.0%
BFS	179.4%	N/A	339.9%	524.4%	345.0%	272.3%	N/A	350.3%	428.3%	156.0%

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

A graphical summary of all of the EV/NPV data for all of the companies in the sample, distinguished by stage of development is provided in the Exhibit, overleaf. Note that, for each type of study, the vertical lines indicate the statistical outliers in the sample (defined as being more than one standard deviation away from the mean of each sample):

Exhibit 170: Graph of EV/NPV (%), whole sample, by company and stage of development (only metals shown)



Source: Edison Investment Research. Note: For each type of study, the vertical lines indicate the statistical outliers in the sample (defined as being more than one standard deviation away from the mean of each sample).

EV/NPV vs discount rates – comparing two Edison analyses

We first introduced differentiated market derived discount rates for companies at different stages of development in our 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 171: 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 metal prices. *As interpreted by Edison Investment Research.

These discount rates form the basis of the valuation of NonSuch Gold on pages 72–74. 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 172: NonSuch Gold EV as a percentage of project NPV, by stage of development

	2018			2017		
Percent	Scoping study/PEA	PFS	BFS	Scoping study/PEA	PFS	BFS
Maximum	51.9	77.0	116.2	50.8	76.0	115.3
Mid	2.7	12.2	26.4	1.4	10.9	25.2
Minimum	-7.7	-3.3	2.3	-9.1	-4.6	-1.0

Source: Edison Investment Research

These may be directly compared with those percentages derived from our EV/NPV analysis in Exhibit 166, presented below transposed for easier comparison:

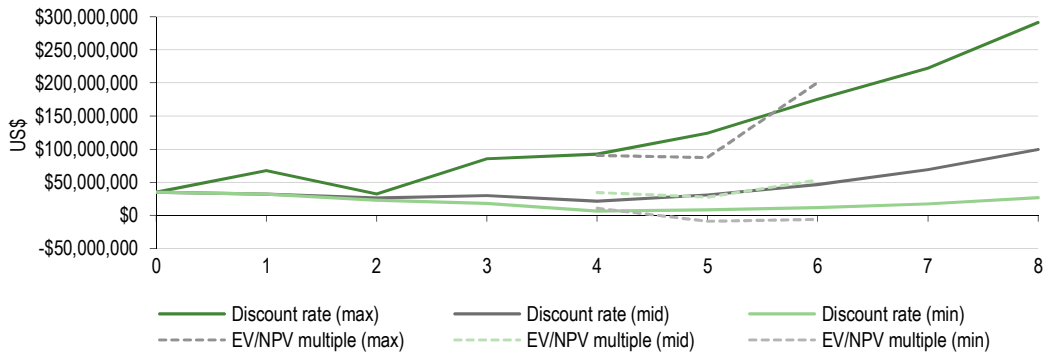
Exhibit 173: Company EV as percent of attributable project NPV (%), by study type, ordinarily valued companies, excluding statistical outliers

Percent	Scoping study/PEA	PFS	BFS
Maximum	50.7	51.3	133.5
Mean	11.7	9.9	30.9
Minimum	-4.8	-15.4	-10.1

Source: Edison Investment Research

By contrast, if NonSuch Gold were to be valued according to the percentages derived from our EV/NPV analysis (Exhibits 166 and 173, above), then its valuation, depicted graphically, would compare to those derived using discount rates, as follows:

Exhibit 174: 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 are the following:

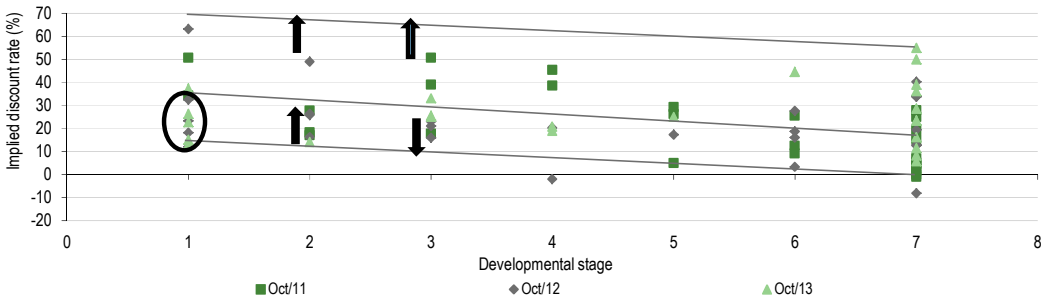
- The close correlation of the valuation results for companies at PEA stage at the bottom end of the valuation range by the two different methods of calculation.
- The close correlation of the valuation results for companies in the middle of the valuation range at BFS and PFS stage, in particular, by the two different methods of calculation.
- The close correlation of the valuation results for companies at the top end of the valuation range at PEA stage.

Note that, where anomalies between the two valuation methodologies exist, in the majority of cases, they reflect the pattern observed hitherto and commented upon subsequently, whereby the valuation range is narrower and the mean lower for PFS stage projects compared to PEA level ones. In terms of the discount rates used by Edison, it could imply:

- That we should give more weight to the greater concentration of companies with lower implied discount rates at PEA level (as depicted by the oval in Exhibit 175).
- That the lines in the graph below may be discontinuous – especially at PFS stage – where there may be a 'kink' upwards in the lines.
- That the lines in the graph at BFS stage may 'blow out' (as depicted by the ovals below).

In summary, we are 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, we recognise that, in comparison to our 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 – and potentially expands – into the PFS stage, in part depending on how the IRR of the project develops as it makes the transition.

Exhibit 175: 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, we analyse company valuations with respect to five variables in order to attempt to estimate the importance of each in determining the success of junior mining companies. The five variables are:

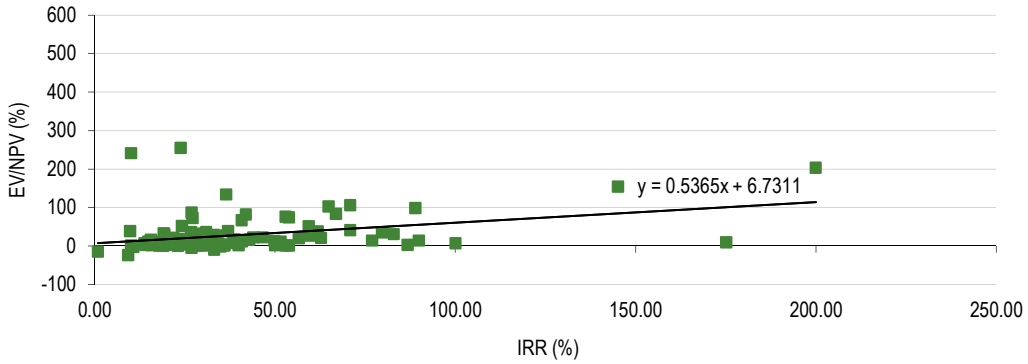
- Project internal rates of return (IRR).
- The Fraser Institute index of Investment Attractiveness for the country or jurisdiction in which a company's project (or projects) are located.
- Project size.
- Project grade.
- Product/product price.

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.

A scattergram of EV/NPV vs IRR is as follows:

Exhibit 176: Company EV as percent of attributable project NPV (%) vs project IRR (%)

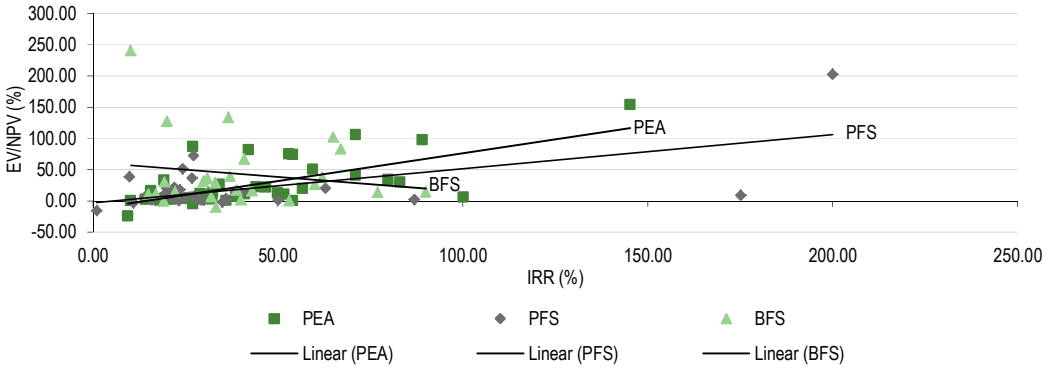


Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Compared with the same analysis in 2017, which was conducted on a materially smaller sample, the correlation between IRR and EV/NPV has improved markedly in 2018, with a Pearson product moment coefficient of 0.35 (cf 0.186 in 2017), which is statistically significant at the 5% level, given the number of data points analyses. In addition, the error of estimation is a much narrower ±44.8% (cf 91.2% previously).

If the analysis is differentiated by study type however, a more nuanced pattern emerges:

Exhibit 177: 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 can be seen to clearly decline from a Pearson product moment coefficient for companies at PEA stage of 0.68 (ie statistically significant at the 5% level) to one of -0.19 (ie negative and not statistically significant) for companies at BFS stage – which is consistent with 2017, when the equivalent correlation coefficients were 0.79 and -0.09, respectively.

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 that the best-fit lines expressing the relationship between EV/NPV and IRR imply that a company at PEA stage needs to have a project with an IRR of at least 14.0% in order to attract a positive valuation (cf 19.4% last year), while a company at PFS stage needs to have an IRR of at least 5.5% in order to cross the same threshold.

Of equal note however is the fact that the overwhelming majority of companies with the highest valuations (ie EV/NPV) all have projects located in jurisdictions that are, by common consent, perceived as low risk, such as NAFTA or Western Australia. This could imply that company valuations are closely related to the country or jurisdiction in which a project is located and gives rise to the second of our analyses of this type, below.

The Fraser Institute Investment Attractiveness Index

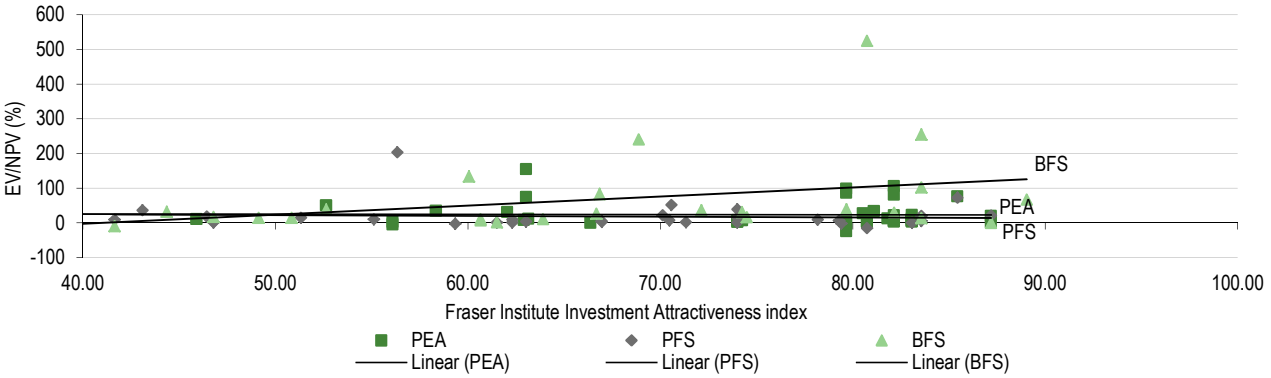
There are so many facets of any one country's economy, legal framework and infrastructural characteristics (to name but a few) that it is difficult to find a single measure by which to rank them generally, let alone for mining specifically. Every year however, the Fraser Institute produces an Annual 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, according to the 2017 Global Go To Think Tank Index published by the University of Pennsylvania and released in Washington, DC, was Canada's top think-tank for the 10th successive year and among the top 25 think-tanks globally.

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 2017, 91 jurisdictions were surveyed, returning Investment Attractiveness Index ratings from 26.96 (for Guatemala) to 89.04 for Finland.

Given our observation above, 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 178: Company EV as percent of attributable project NPV (%) vs Fraser Institute Mining Investment Attractiveness Index score, by study type

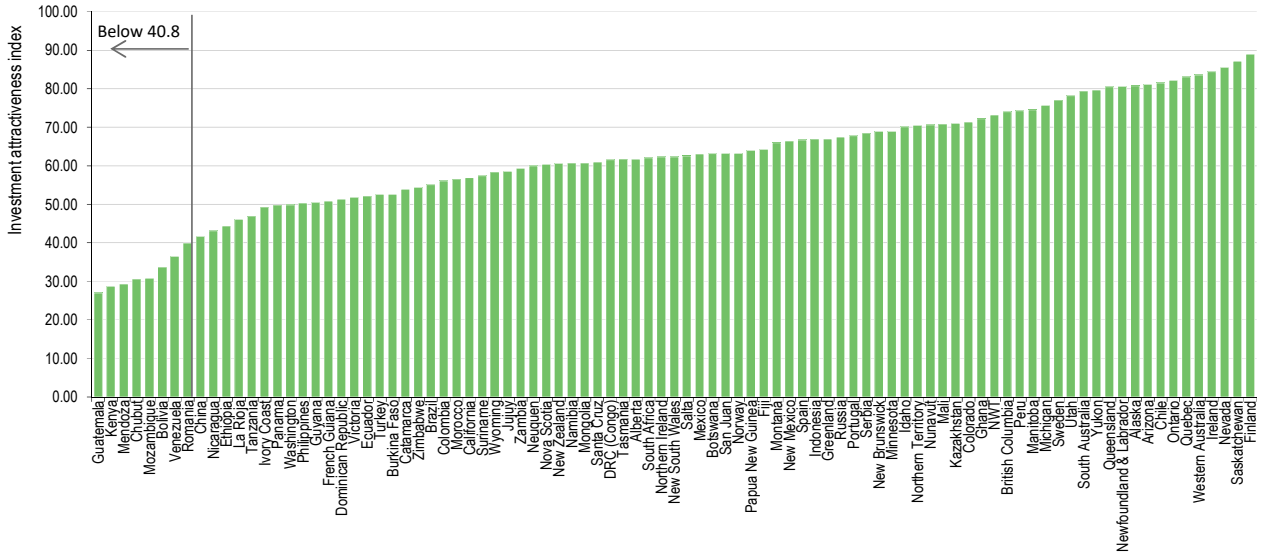


Source: Fraser Institute, Edison Investment Research, Thomson Reuters Datastream, company sources

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 0.10 (cf 0.05 in 2017), with a high error of estimation of ±68.3%.
- Nevertheless, within the context of a low overall correlation, the Pearson product-moment coefficient is markedly higher for companies with projects at BFS level (+0.34) compared to companies at PEA and PFS level, for which the correlation is weak and (surprisingly) negative. Note that, given the number of data points in the sample, a correlation coefficient of 0.34 between Fraser Institute score and valuation is nevertheless statistically significant at the 5% level.
- The gradient of the line of best fit for companies with projects at BFS level (excluding outliers) is such that it implies that a company in a jurisdiction with a Fraser Institute Investment Attractiveness Index score of 40.8 (all other things being equal) would have an EV of zero. This encompasses the bottom eight jurisdictions in the Fraser Institute's 2017 survey (published in February 2018):

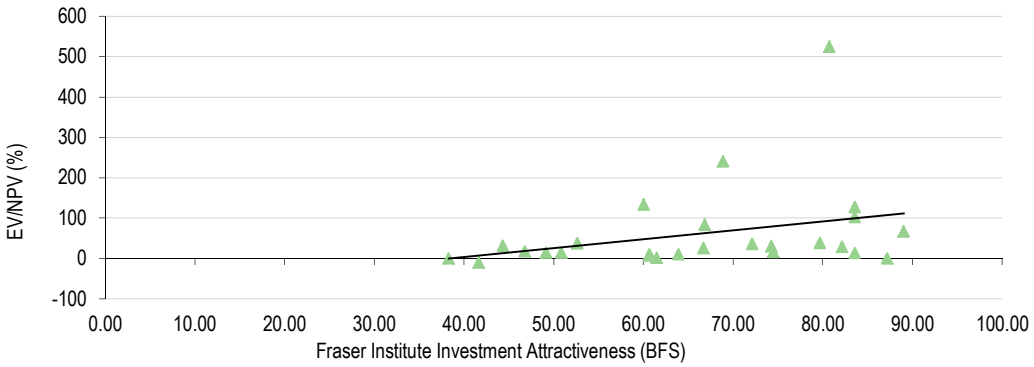
Exhibit 179: Fraser Institute Investment Attractiveness Index, 2017



Source: Fraser Institute, Edison Investment Research

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



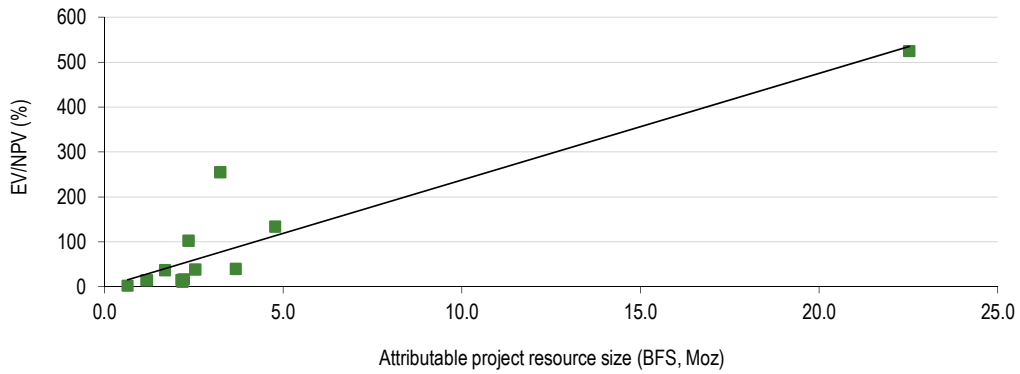
Source: Fraser Institute, Edison Investment Research, Thomson Reuters Datastream, company sources

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 the 34 gold companies within the broader sample.

For size, the correlation is poor over the whole sample, with a Pearson product moment (correlation) coefficient of 0.11. Considered in terms of the stage of development however, while the individual correlation coefficients for PEA and PFS stage companies are (just) not statistically significant at the 5% level, it is for BFS stage companies, as shown below:

Exhibit 181: Company EV as percent of attributable project NPV (%) vs attributable resource size (Moz), BFS stage companies only



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

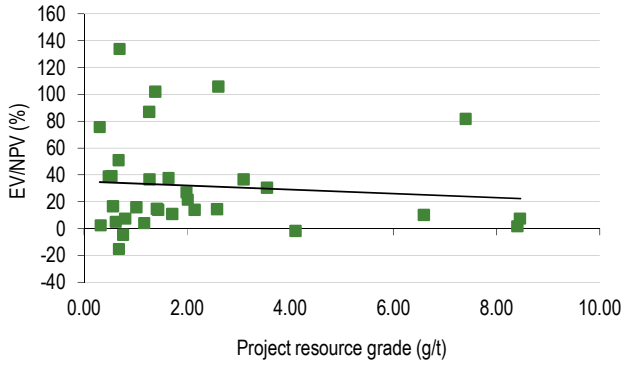
Note that, while the correlation is materially influenced by the data point to the top-right of the chart, removing still results in a statistically significant correlation at the 5% level.

Compared to 2017's analysis, it can be said that, while the same trend prevails in 2018, in general the correlation (either positive or negative) between (gold) project size and company valuation for companies at different stages of development has become more pronounced since a year ago (see Exhibits 185 and 186).

Project grade

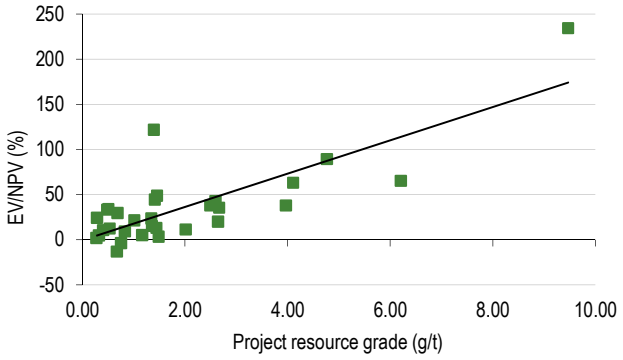
In contrast to the size:valuation relationship, which appears to have become more pronounced over the course of the last year, the grade:valuation relationship appears to have become weaker:

Exhibit 182: Company EV as percent of attributable project NPV (%) vs project resource grade, excluding outliers, 2018



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

Exhibit 183: Company EV as percent of attributable project NPV (%) vs project resource grade, excluding outliers, 2017



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

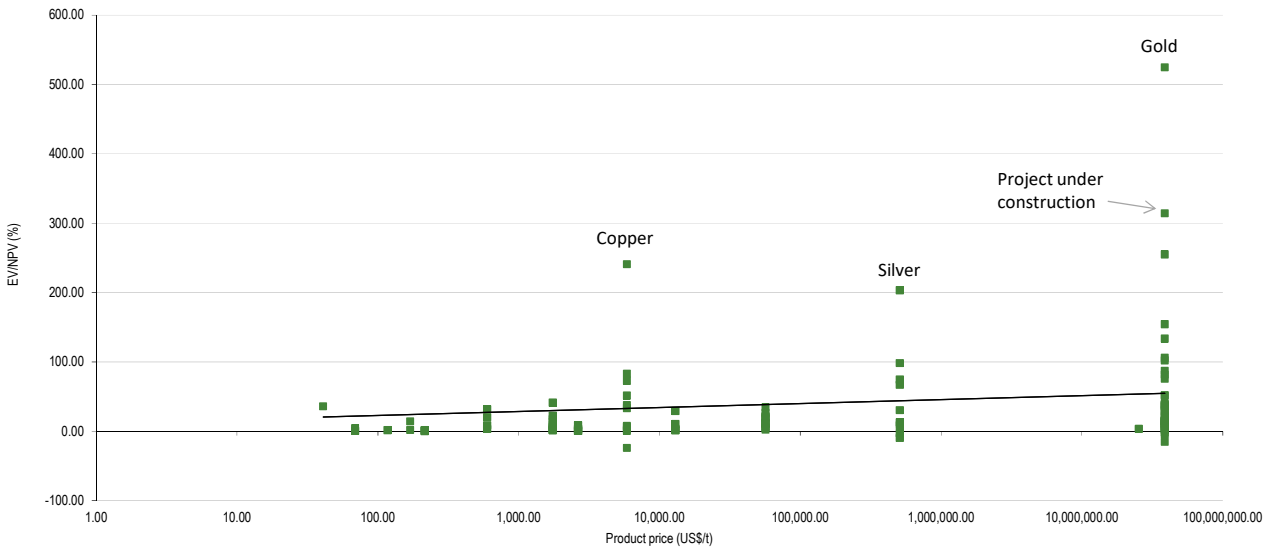
Whereas the overall grade:valuation relationship was weak in 2017, it was noticeably strong if (valuation) outliers were removed from the sample, in particular, and also in the cases of companies at PEA and PFS stage of development. This appears not to be the case in 2018, where the overall correlation is weak, but does not improve either when (valuation) outliers are removed or when the analysis is considered in terms of companies' stages of development. We have no particular explanation for this change over the course of the past year, other than the *prima facie* observation that there appear to be more companies with grades between 0.0–3.0g/t with higher valuations compared to last year and more high-grade companies (eg 6.0–9.0g/t) with lower valuations.

Clearly, this (slightly unexpected) result could be an anomaly, or 2017's result could have been an anomaly. Alternatively, the result could be regarded as evidence that gold investors, in particular, are moving away from the erstwhile mantra of 'grade, grade, grade'. From a statistical perspective, it certainly remains the case that there is an extremely poor relationship between grade and IRR and this is perhaps also evidence that investors are becoming more nuanced in their appreciation of the contribution of grade (within the context of other factors) towards overall investment returns to equity holders. Either way, we will keep monitoring the relationship over time to ascertain which of these possible scenarios seems to be the more likely.

Product/product price

In a departure from 2017, in 2018, we performed one additional analysis involving one additional factor considered of potential importance in conferring value on mining companies, namely product (as distinguished by their prices). In this case, the resulting scattergram of the relationship between price and company valuation is as follows. Note that each 'column' effectively represents a different metal or mineral.

Exhibit 184: Graph of product price (US$/t) vs EV/NPV (%), whole sample



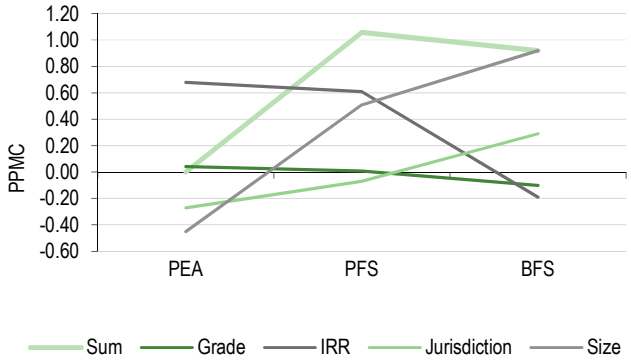
Source: Edison Investment Research. Note: From left to right, columns represent bauxite, iron ore, thermal coal, met coal, MOP, SOP, graphite, zinc, copper, nickel, uranium, silver, platinum, gold.

At 0.24, the overall correlation between product price and valuation was weak and not statistically significant. Considered in relation to stage of development, the correlation was statistically significant at PEA stage only. However, it does not appear logical to us that the relationship between product (or product price) and valuation should vary across the three different stages of development. Instead our hypothesis is that, at every stage, a particular product would (or should) support either consistently higher or lower valuations. The best-fit line is shown on the graph and shows a positive gradient, indicating that higher metal prices conform to higher valuations, in general. More strikingly however, we have marked out three 'columns', namely copper, silver and gold, for which not only the size of the average valuation, but also the range of potential valuations appears much larger than for other metals/minerals. Subjectively speaking, we do not believe that it is a coincidence that the potential valuation ranges for what are probably the best-known and best-followed metals within the sector are wider than for the remainder of the metals/minerals in our sample. By the same token however, we also cannot help observing the corollary of this argument, which must be that some of the biggest opportunities for investors may lie in metals/minerals with which investors are less familiar.

Conclusions

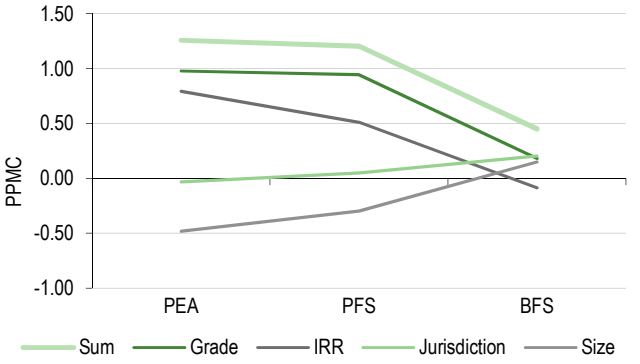
A graph comparing the contributions of each of the four factors considered above (as determined by their correlation coefficients – ie excluding product/product price) to the valuations of companies at various stages of development for both 2018 and 2017 (although not explicitly published in November 2017's report) is provided below:

Exhibit 185: Graph of PPMC vs stage of development for four factors influencing valuation, 2018



Source: Edison Investment Research. Note: PPMC = Pearson product moment coefficient.

Exhibit 186: Graph of PPMC vs stage of development for four factors influencing valuation, 2017



Source: Edison Investment Research. Note: PPMC = Pearson product moment coefficient.

In comparing 2018's results with those of 2017, a number of factors are apparent:

- As in 2017, IRRs remain very important at early-stage, PEA level, projects, but become less so as the project is developed through to BFS.
- Jurisdiction has become more important to company valuations at BFS stage in 2018 than in 2017. At PEA stage, it appears that the correlation is negative, implying that investors have a preference for poor project locations at earlier stages of development. This could be an anomaly or evidence of early-stage risk taking by mining investors.
- Unlike in 2017, project size appears to be very important in contributing to valuations for companies at BFS stage. Interestingly however, as in 2017, project resource size actually appears to detract from companies' valuations at early stages of development.
- In contrast to 2017, investors in 2018 appear to regard grade as much less important in contributing towards a company's valuation. This could be an anomaly or, as discussed above, this could be regarded as evidence that investors are moving away from the erstwhile mantra of 'grade, grade, grade'. From a statistical perspective, it certainly remains the case that there is an extremely poor relationship between grade and IRR and this is perhaps also evidence that investors are becoming more nuanced in their appreciation of the contribution of grade (within the context of other factors) towards overall investment returns to equity holders.

Qualitatively, we posit 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 we have identified – ie engineering, metallurgy or, in particular, management. In our 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. That being the case, considering the graphs above (Exhibits 185 and 186), this factor (ie management) could therefore be said to largely occupy the difference between the sum of the four factors so far

considered and the number one (ie if the sum of the four factors is 0.75, then those four factors could be said to explain 75% of a company's valuation and we hypothesise that management might explain the remaining 25%). In 2017 therefore, at PEA and PFS stage, the valuation of a company could (apparently) be explained almost exclusively in terms of its IRR and its grade. It was only later, at BFS stage, that other factors (eg management, in particular) could be considered as becoming material in determining a company's valuation. In 2018 by contrast, the EV of a company at PFS and/or BFS stage can (apparently) be explained almost exclusively in terms of its IRR and size and it is only at earlier (ie PEA) stage that the contribution of management may be considered as material or significant in contributing to its valuation.

Parthian shot?

In keeping with the rest of this report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the EV/NPV analysis and five factors that are presumed to influence their valuations, namely sovereign risk (as measured by the Fraser Institute), project IRR, project NPV, the type of study performed and the discount rate used. In simple terms, the analysis asserts that a company's EV should be a function of these five factors (albeit, note that only two are the same as those considered hitherto). The multiple regression analysis therefore plots EVs of the companies against these five factors (effectively in six dimensions) and then calculates the best-fit line between the points. In this case, the formula for the best-fit line (in US$m) derived via such an analysis is as follows:

EV = 264.9 + (0.09 × Fraser) + (0.5 × IRR) + (0.04 × NPV in millions) − (2.4 × study type) − (30.8 × discount rate)

The results should probably be taken with a pinch of salt. Self-evidently, NPV and discount rate are not independent of one another, which raises issues of multicollinearity in the analysis. Nevertheless, without going into the details unnecessarily, suffice it to say that there is a good level of confidence surrounding the factors shown relating to the 'intercept', the project NPV and the discount rate and there is a degree of confidence surrounding the factor relating to the IRR.

A number of features of the equation are otherwise apparent:

- Statistically speaking, on average, each percentage increase in the discount rate reduces a company's EV by US$30.8m.
- For these purposes, the study types are arbitrarily defined as PEA (1), PFS (2) and BFS (3). Empirically, this implies that a PFS is considered to be twice as good as a PEA (the relationship of 2 to 1) and a BFS is considered to be 50% better than a PFS (the relationship of the number 3 to the number 2). These might suffice for the moment, but they could probably be better defined in terms of their cost accuracy (eg PFS 75%, BFS 90% etc). In this case, improving a study from PEA to PFS would reduce a company's EV by US$2.4m, on average – which is consistent with our earlier EV/NPV analysis (pages 75–84, above). Increasing it again however, from a PFS to a BFS, would then reduce the company's EV by another US$2.4m, which is inconsistent with our earlier findings and counter-intuitive.
- Every US$1m added to a company's project's NPV will add, on average, US$0.04m to its EV.
- Every percentage point that is added to a company's project's IRR will add, on average, US$0.5m to its EV.
- Every point by which a country increases its Fraser Index score of Investment Attractiveness will increase the EVs of the explorers operating within its borders by US$0.09m.
- The 'intercept' of the equation appears very high, but is very largely set off by the (negative) factor applied to the discount rate.

Whatever else, this equation appears to support our earlier findings of a relatively weak effect on valuations from sovereign risk (as measured by the Fraser Index) and a larger one from project IRRs.

If a wholly 'average' company is considered, with 100% ownership of a project with an NPV of US$648.8m, an IRR of 40.1%, operating in a jurisdiction with an average Fraser Institute Investment Attractiveness rating of 61.97 (roughly the equivalent of South Africa in the latest survey), at PFS stage and using an 8% discount rate, then the implied EV of the company, as derived using the above equation, would be US$65.6m, or 10.1% of the NPV of the project. This compares with our earlier observation, that companies at PFS stage trade, on average, at 18.2% of the attributable NPV of their project or 9.9% if statistical outliers are excluded from the sub-sample. Readers are invited to come to their own conclusions regarding the veracity and accuracy of the equation within the context of this result. In our opinion, it seems (surprisingly) accurate.

Discount rate analysis

As indicated previously, the EV/NPV analysis conducted between pages 75 and 84 was done at a variety of discount rates, which are summarised in the table below:

Exhibit 187: Discount rates at which EV/NPV analysis conducted

Discount rate (%)	5%	6%	6.5%	7%	7.5%	8%	9%	10%	11%	12%	Total
Number of companies within sample	26	0	1	3	4	55	0	12	0	1	102
Percentage of total (%)	25.5	0.0	1.0	2.9	3.9	53.9	0.0	11.8	0.0	1.0	100.0

Source: Edison Investment Research, company data

This might be summarised as, half of all mining project NPV analyses are conducted at a discount rate of 8%, while a quarter are conducted at 5% and an eighth at 10%. The remaining eighth are conducted at a variety of rates, ranging from 6.5% to 12%.

The intention of this section is to perform the same analysis as that above, in the 'EV/NPV: A key transition' section on pages 75–84, at a single discount rate (in this case 8%).

Broken down by principal commodity, the sample of companies studied at a purely 8% discount rate (cf the whole sample) is as follows:

Exhibit 188: Price: NPV analysis sample size, by commodity

	8% sample		Whole sample	
Commodity	Number of companies	Percentage of total (%)	Number of companies	Percentage of total (%)
Gold	10	18	34	33
Uranium	14	25	14	14
Copper	5	9	10	10
Silver	7	13	11	11
Zinc	4	7	4	4
MOP	1	2	3	3
Graphite	4	7	11	11
PGM	0	0	2	2
Nickel	4	7	4	4
Iron ore	2	4	4	4
Met coal	1	2	2	2
SOP (brine)	2	4	2	2
SOP	1	2	1	1
Total	**55**	**100**	**102**	**100**

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

Of note is the fact that, relative to the whole sample, gold projects appear to be under-represented in the 8% sample, while uranium projects appear to be over-represented – which might have an effect on the sample within the context of our 'Product/product price' analysis on page 93, although this has not been investigated in this report.

Within this context, the range of project NPVs and IRRs within the sample is as follows:

Exhibit 189: Project NPV and IRR sample, range and averages

	8% sample		Whole sample	
	IRRs (%)	NPVs (US$m)	IRRs (%)	NPVs (US$m)
Maximum	175.2	4,800.0	200.0	7,000.0
Mean	**41.4**	**659.3**	**40.1**	**648.8**
Minimum	9.4	-11.0	1.0	-552.0

Source: Edison Investment Research, company sources

On first impression, therefore, the sample of companies for which projects have been evaluated using a discount rate of 8% is comparable to the broader one conducted at a range of discount rates.

Relating company valuations to project economics

As with the broader sample, the key valuation 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), albeit conducted at a single discount rate (8%). Comparing the two:

Exhibit 190: Company EV/NPV (%), range and averages, 2018 8% discount rate sample vs 2018 whole sample

	2018 8% discount rate sample only	2018 whole sample
Maximum	154.18	524.4
Mean	**20.38**	**33.1**
Minimum	-24.30	-24.3

Source: Edison Investment Research

Of immediate note is the lower average valuation for companies in the 8% sample relative to the valuation of those in the broader sample. This seems counter-intuitive as, after the 8% sample, the next largest sub-sample, by discount rate, was the 5% sub-sample, which might have been expected to relatively inflate NPVs and therefore result in lower EV/NPV ratios within the broader sample, all other things being equal. This unexpected result could be taken as *prima facie* evidence that investors interpret higher discount rates as relating to lower quality projects and then valuing the host company at a lower percentage of NPV regardless of any consideration for the discount rate used.

Broken down by stage of development, a summary of the data, in tabular form, is as follows:

Exhibit 191: Company EV as percent of attributable project NPV (%), by study type, summary

	8% only sample				Whole sample			
Study type	**Minimum**	**Mean**	**Maximum**	**Range**	**Minimum**	**Mean**	**Maximum**	**Range**
PEA	-24.3%	23.2%	154.2%	178.5%	-24.3%	24.1%	154.2%	178.5%
PFS	-2.9%	11.4%	51.3%	54.2%	-15.4%	18.2%	202.9%	218.3%
BFS	-10.1%	28.4%	101.9%	112.0%	-10.1%	66.5%	524.4%	534.5%
All studies	**-24.3%**	**20.4%**	**154.2%**	**178.5%**	**-24.3%**	**33.1%**	**524.4%**	**548.7%**

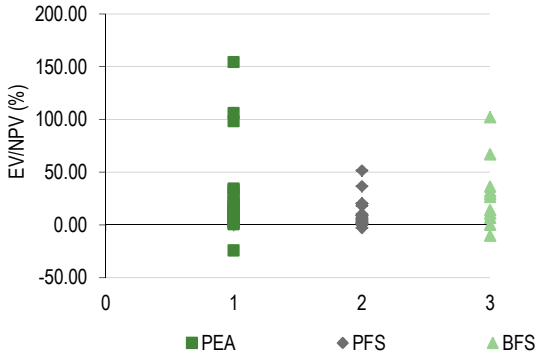
Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Compared with the whole sample, a number of observations can be made:

- While minimum valuations across all study types in the 8% sample are comparable to those in the whole sample, maximum valuations are quite materially lower (with the exception of PEA stage companies), with the result that the range of valuations is also much lower – although, note that this may be a sampling effect rather than anything else.
- Mean valuations become proportionately lower for the 8% sample relative to the broader sample as stage of development advances.

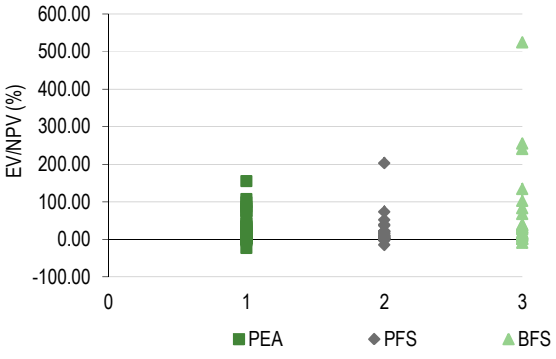
The same data may also be depicted as follows in comparison to the broader sample:

Exhibit 192: Company EV as percent of attributable project NPV (%), by study type, 8% sample



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

Exhibit 193: Company EV as percent of attributable project NPV (%), by study type, whole sample



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

Excluding outliers (using the same definition as an outlier being more than one standard deviation away from the mean), the 8% sample may be compared to the broader sample thus:

Exhibit 194: Company EV as percent of attributable project NPV (%), by study type, ordinarily valued companies, excluding statistical outliers

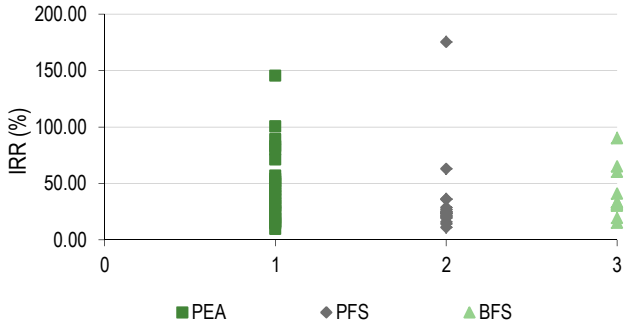
	8% sample				Whole sample			
Study type	Minimum valuation	Mean valuation	Maximum valuation	Range	Minimum valuation	Mean valuation	Maximum valuation	Range
PEA	0.2%	12.3%	34.1%	33.9%	-4.8%	11.7%	50.7%	55.5%
PFS	-2.0%	8.0%	20.3%	22.3%	-15.4%	9.9%	51.3%	66.7%
BFS	-2.1%	19.3%	36.3%	38.4%	-10.1%	30.9%	133.5%	143.6%

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

Three features are, once again, notable:

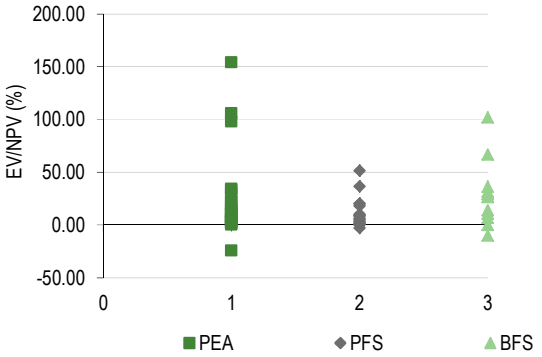
- The much closer alignment of the mean valuation and the (presumed) mode for the 8% sample. NB As expected and as observed for the whole sample.
- The mean valuations for companies at PEA and PFS stage are comparable between the 8% sample and the whole sample. The mean valuation for companies at BFS stage is materially lower for the 8% sample compared to the whole sample.
- The apparent 'anomaly', whereby the mean is lower for PFS compared with PEA level projects nevertheless remains. As for the whole sample, this may be explained for the 8% sample by the generally higher IRRs associated with PEA stage projects compared to PFS ones (see graphs below). However, it may also be a persistent feature of mining company valuations in general (our supposition, given the persistence of this pattern throughout the report):

Exhibit 195: Project IRRs, by study type (%), 2018, 8% sample



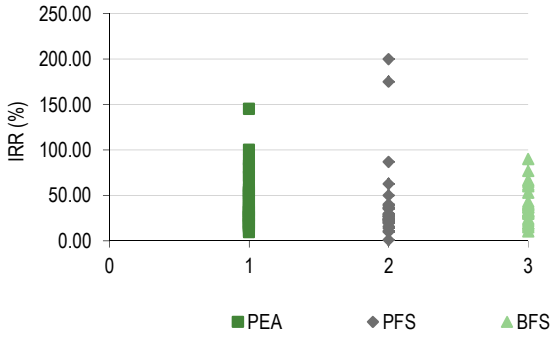
Source: Edison Investment Research, company sources

Exhibit 196: Company EV as percent of attributable project NPV (%), by study type, 2018, 8% sample



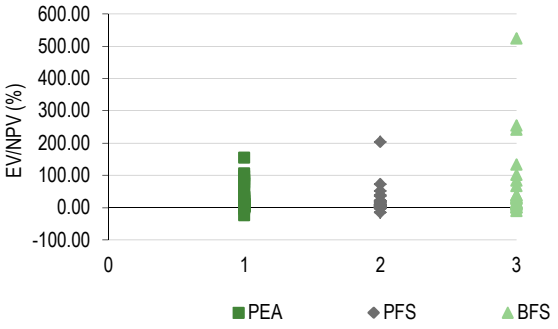
Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Exhibit 197: Project IRRs, by study type (%), 2018, whole sample



Source: Edison Investment Research, company sources

Exhibit 198: Company EV as percent of attributable project NPV (%), by study type, 2018, whole sample



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

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

Exhibit 199: Company EV as percent of attributable project NPV (%), by study type, exceptionally valued companies

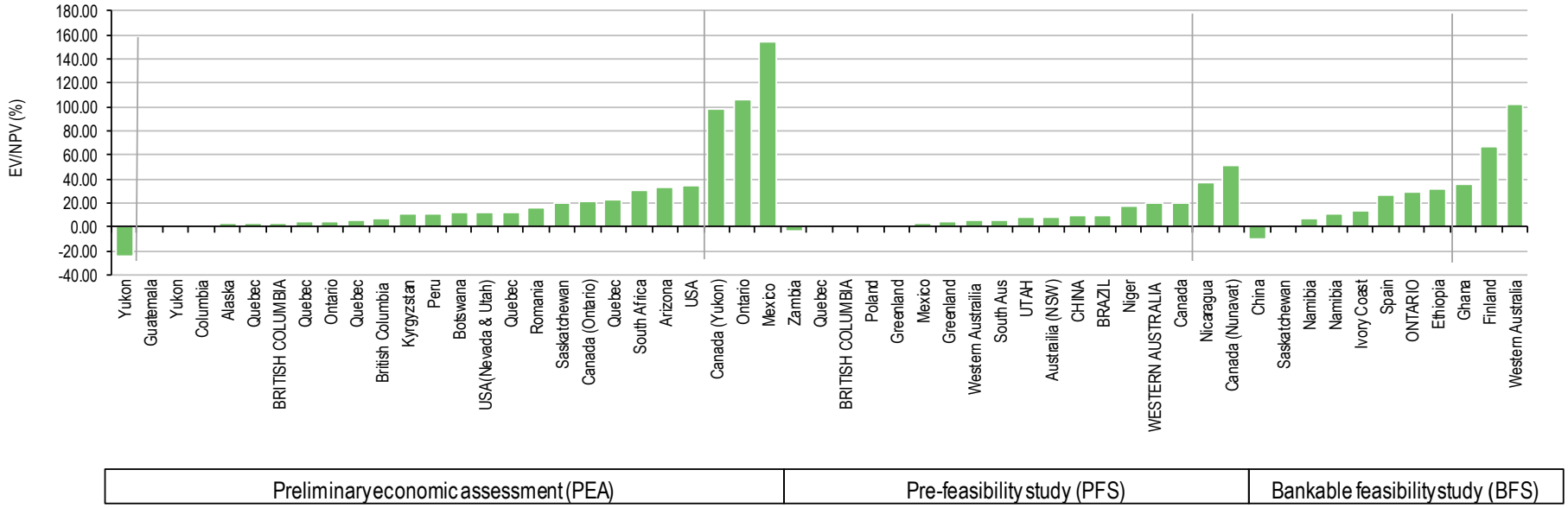
	8% sample					Whole sample				
Study type	Minimum valuation	Distribution mode	Mean valuation	Maximum valuation	Range	Minimum valuation	Distribution mode	Mean valuation	Maximum valuation	Range
PEA	60.8%	N/A	119.2%	154.2%	93.4%	59.1%	N/A	96.5%	154.2%	95.1%
PFS	24.7%	N/A	43.9%	51.3%	26.6%	56.0%	N/A	137.6%	202.9%	146.9%
BFS	58.9%	N/A	84.3%	101.9%	43.0%	179.4%	N/A	339.9%	524.4%	345.0%

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

Notably, the maximum, minimum and mean valuations for companies at PEA stage in the 8% sample compares closely with that of the whole sample. Thereafter, the discount of valuations in the 8% sample increases relative to that of the whole sample as projects' stages of development advance.

A graphical summary of all of the EV/NPV data for all of the companies in the sample, distinguished by stage of development is provided in the exhibit overleaf. Note that, for each type of study, the vertical lines indicate the statistical outliers in the sample (defined as being more than one standard deviation away from the mean of each sample):

Exhibit 200: Graph of EV/NPV (%), 8% sample, by company and stage of development (country of operations shown only)



Source: Edison Investment Research. Note: For each type of study, the vertical lines indicate the statistical outliers in the sample (defined as being more than one standard deviation away from the mean of each sample).

EV/NPV vs discount rates – comparing two Edison analyses

We first introduced differentiated market derived discount rates for companies at different stages of development in our report Gold: New benchmarks for old, published in November 2012, and updated them in subsequent reports. As in the 'EV/NPV: A key transition' section, our most recently updated discount rates (to be applied to dividends rather than cash flows) are as follows:

Exhibit 201: 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 metal 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 an 8% discount rate, applied to cash flows in the conventional manner), these discount rates yield the following percentages at the comparable PEA, PFS and BFS project stages:

Exhibit 202: NonSuch Gold EV as a percentage of project NPV, by stage of development

Percent	Scoping study/PEA	PFS	BFS
Maximum	43.0	63.9	96.4
Mid	2.3	10.1	21.9
Minimum	-6.4	-2.7	1.9

Source: Edison Investment Research

These may be directly compared with those percentages derived from our EV/NPV analysis in Exhibit 194, presented below transposed for easier comparison (and also with those of the broader sample – see Exhibit 166):

Exhibit 203: Company EV as percent of attributable project NPV (%), by study type, ordinarily valued companies, excluding statistical outliers (8% sample vs whole sample)

	8% sample			Whole sample		
Percent	Scoping study/PEA	PFS	BFS	Scoping study/PEA	PFS	BFS
Maximum	34.1	20.3	36.3	50.7	51.3	133.5
Mean	12.3	8.0	19.3	11.7	9.9	30.9
Minimum	0.2	-2.0	-2.1	-4.8	-15.4	-10.1

Source: Edison Investment Research

Since the whole sample includes a large percentage of projects valued using a 5% discount rate, resulting in larger NPVs (all other things being equal), it would be logical to expect that this sample would be characterised by lower valuation percentages. In general however, the opposite appears to be the case.

In the case of NonSuch Gold however, the NPV_8 is 20.5% higher than its NPV_{10}. Yet it is only at the maximum valuations at PFS and BFS stages that the corresponding EV/NPV valuation percentages are more than 20.5 percentage points higher for the whole sample, rather than the 8% sample – ie implying that a valuation derived from the benchmarks calculated from the 8% sample may well be higher than those calculated from the whole sample. Note however that this is a characteristic peculiar to a company with a project valued at discount rate higher than 8%. Within this context, it is useful to view a range of NPVs for NonSuch Gold's project and to observe how they vary with the discount rate applied:

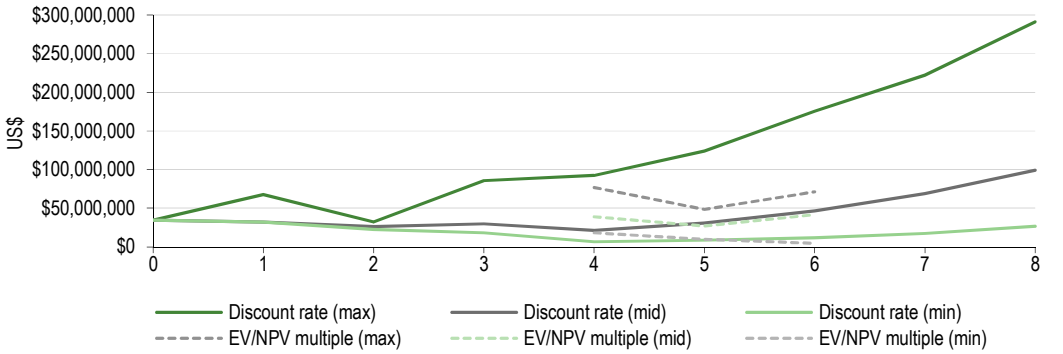
Exhibit 204: NonSuch Gold project valuation at varying discount rates

Discount rate (%)	NPV (US$m)	Change vs 12% discount rate	Change vs 10% discount rate	Change vs 8% discount rate	Change vs 7.5% discount rate	Change vs 7% discount rate	Change vs 6.5% discount rate	Change vs 5% discount rate
5.0	229.1	92.4	59.2	32.1	26.2	20.4	11.8	0.0
6.5	204.9	72.0	42.4	18.2	12.8	7.7	0.0	-10.6
7.0	190.3	59.8	32.2	9.7	4.8	0.0	-7.1	-16.9
7.5	181.6	52.5	26.2	4.7	0.0	-4.6	-11.4	-20.7
8.0	173.4	45.6	20.5	0.0	-4.5	-8.9	-15.4	-24.3
10	143.9	20.8	0.0	-17.0	-20.8	-24.4	-29.8	-37.2
12	119.1	0.0	-17.2	-31.3	-34.4	-37.4	-41.9	-48.0

Source: Edison Investment Research

If NonSuch Gold were then to be valued according to the percentages derived from our EV/NPV analysis using the 8% sample (Exhibits 194 and 203, above), its valuation, depicted graphically, would compare to those derived using discount rates, as follows:

Exhibit 205: NonSuch Gold valued with respect to 1) discount rates and 2) EV/NPV multiples (based on 8% sample), compared (US$)

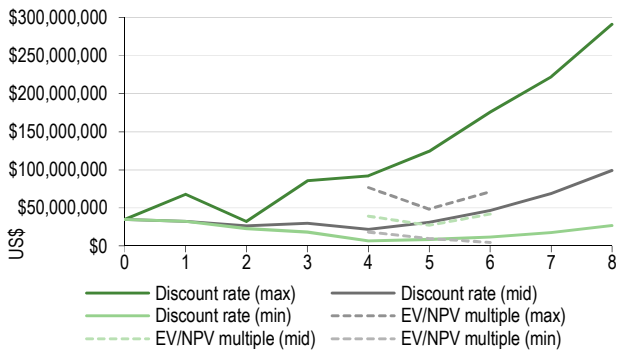


Source: Edison Investment Research. Note: 4 – Scoping study/preliminary economic assessment (PEA); 5 – Pre-feasibility study (PFS); 6 – Bankable feasibility study (BFS); 7 – Development; 8 – Production ramp-up.

Note that, as before, 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.

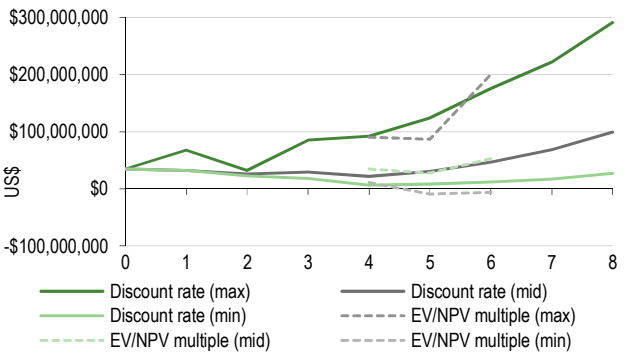
The comparison with the equivalent result using the whole sample of discount rates is as follows:

Exhibit 206: NonSuch Gold valued with respect to 1) discount rates and 2) EV/NPV multiples (8% sample), 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.

Exhibit 207: NonSuch Gold valued with respect to 1) discount rates and 2) EV/NPV multiples (whole sample), 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 the anomaly, whereby the valuation range is narrower and the mean lower for PFS compared to PEA level projects remains in the analysis using the 8% sample, as for that using the whole sample.

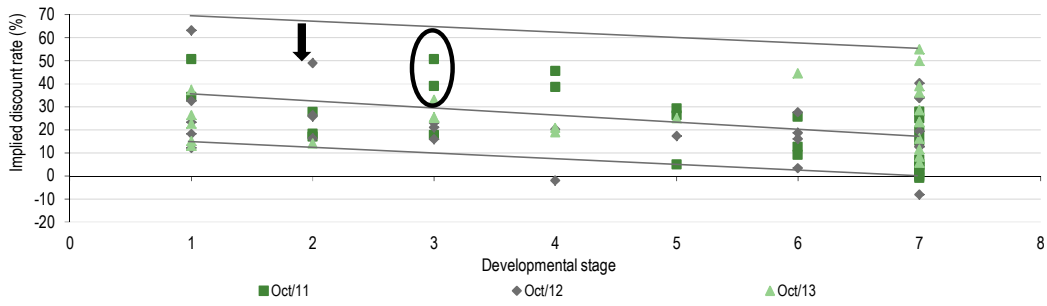
Otherwise, several features are notable:

- Using the valuations derived from our earlier work on discount rates as a benchmark, the EV/NPV analysis (based on the whole sample) is a much better predictor of valuations at earlier stages of development and also towards the upper end of the valuation range.
- The EV/NPV analysis (based on a specific discount rate) is a much better predictor of valuations at later stages of development and also towards the lower end of the valuation range.
- With the exception of the most heavily discounted companies, valuations based on an EV/NPV methodology can use the parameters derived from the whole sample of projects at a variety of discount rates. Note that, within this context, there is an implication that the market is, to some extent, 'discount rate blind', especially in respect of early stage companies or highly rated companies. An alternative explanation would be that the market is more accepting of the discount rates chosen by the operating companies themselves at earlier stages of development (and higher valuation ranges), but that it becomes more discerning at later stages of development (and lower valuation ranges) and requires that an appropriate discount rate is applied. Specific discount rates therefore need only be used for later stage, or poorly rated companies.

In terms of the discount rates used by Edison (specifically within this later stage, lower valued sample of companies), it could imply:

- That it may be valid to recognise the relative absence of companies with high implied discount rates at PFS stage (as depicted by the arrow).
- That there may be more companies with higher discount rates at BFS level than recognised in our discount rate sample (as depicted by the oval below).

Exhibit 208: 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.

Nevertheless, in conclusion, we are 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) and at a variety of discount rates in the case of the former. Almost incontrovertibly, at this stage, we recognise that, in comparison to our discount rate method, which implies a valuation trough at scoping study stage, all of the EV/NPV methods employed so far, using a variety of discount rates, suggest that this trough extends into PFS stage (all other things being equal).

Conferring exceptionality – four parameters considered

In the following section, we perform the same analysis in respect to two of the five variables considered previously in order to attempt to estimate the importance of each in contributing to the valuations of junior mining companies at a standardised 8% discount rate. The two variables are:

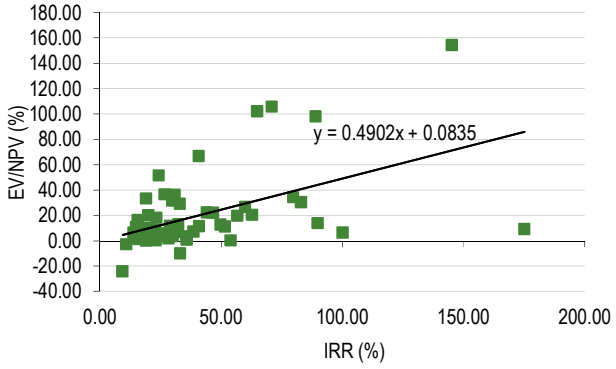
- project internal rates of return (IRR), and
- the Fraser Institute Investment Attractiveness Index for the country or jurisdiction in which a company's project is located.

Internal rates of return (IRR)

Positing the same relationship between a company's valuation and its project IRR, we find that, overall, there is a better correlation for companies and projects restricted to the 8% sample (with a Pearson product moment coefficient of 0.50), rather than companies and projects that are unrestricted with respect to the discount rate applied to the NPV (correlation coefficient of 0.35).

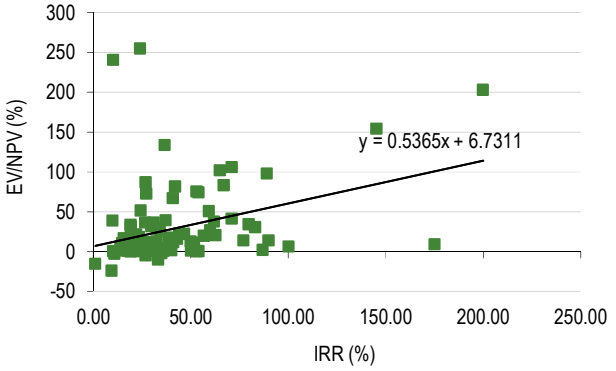
A scattergram of EV/NPV vs IRR is as follows:

Exhibit 209: Company EV as percent of attributable project NPV (%) vs project IRR (%), 8% sample



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

Exhibit 210: Company EV as percent of attributable project NPV (%) vs project IRR (%), whole sample

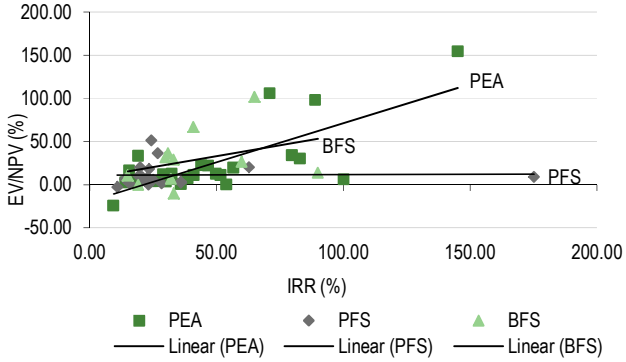


Source: Edison Investment Research, Thomson Reuters Datastream, company sources

Note that, given the sample sizes studied, Pearson product moment coefficients of both 0.50 (8% sample) and 0.35 (whole sample) are statistically significant at the 5% level. Moreover, when only the 8% sample is considered, the best-fit line between the points passes, very nearly, through the graph's origin, which appears logical (see Exhibit 209).

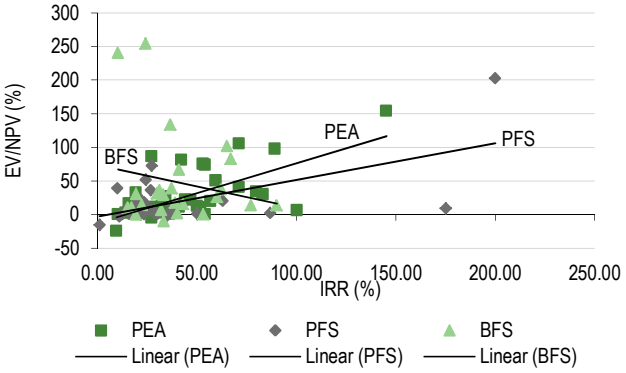
As before however, if the analysis is differentiated by study type, a more nuanced pattern emerges:

Exhibit 211: Company EV as percent of attributable project NPV (%) vs project IRR (%), by study type, 8% sample



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

Exhibit 212: Company EV as percent of attributable project NPV (%) vs project IRR (%), by study type, whole sample



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

Including statistical outliers, the strongest correlation (with a Pearson product moment coefficient of 0.75) arises between a project's IRR and its valuation at PEA stage. This is even stronger than the 0.68 observed for the whole sample. However, for the 8% sample, it then drops off much more steeply, such that it is, to all intents and purposes, irrelevant or random for companies at PFS stage, before reasserting itself with a correlation coefficient (albeit not statistically significant) of 0.35 at BFS stage.

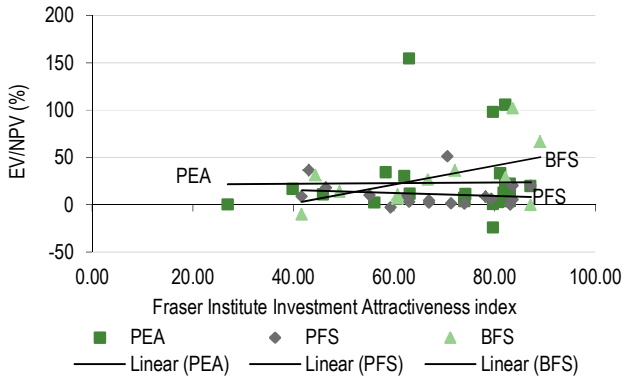
While this casts a little bit of doubt as to the exact importance of a project's IRR in determining a company's valuation at PFS and BFS stage, we can still say that, according to either the 8% sample analysis or the broader sample analysis, it is not statistically significant at the 5% level in the case of either by the time the BFS stage has been reached. It nevertheless reinforces the (positive) relationship between the two at PEA stage.

The Fraser Institute Investment Attractiveness Index

As before, when considering the 8% sample only, the overall correlation between the Fraser Institute's Investment Attractiveness Index and a company's valuation (in the form of its EV/NPV ratio) is weak to the point of randomness, with a correlation coefficient of just 0.11 for the 8% sample (cf 0.10 for the whole sample).

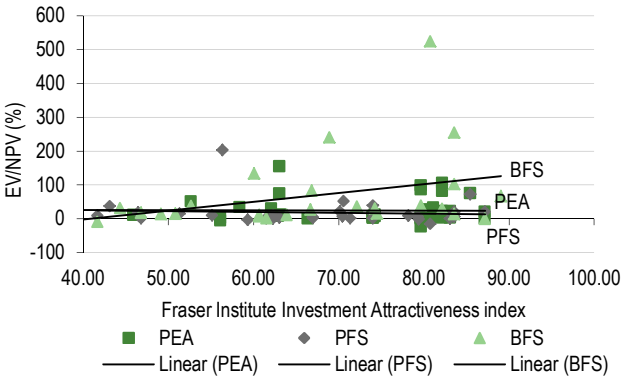
Once again however, the relationship becomes more nuanced if a project's stage of development is considered.

Exhibit 213: Company EV as percent of attributable project NPV (%) vs Fraser Institute Mining Investment Attractiveness Index score, by study type, 8% sample



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

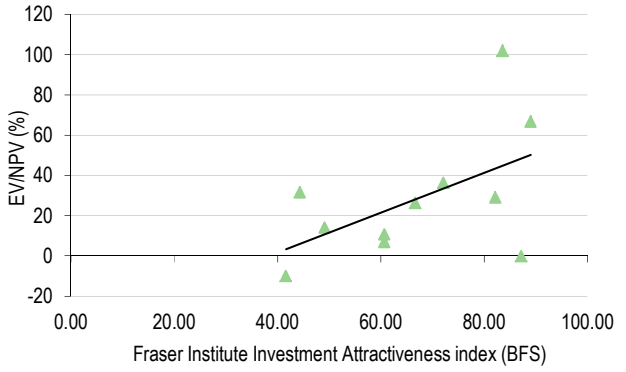
Exhibit 214: Company EV as percent of attributable project NPV (%) vs Fraser Institute Mining Investment Attractiveness Index score, by study type, whole sample



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

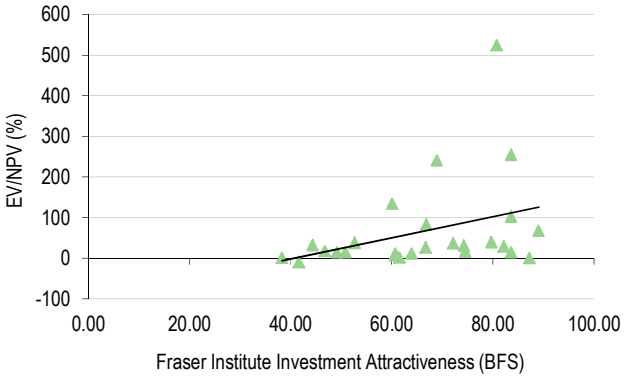
The most striking feature of this analysis is that, for the 8% sample only and excluding statistical outliers, the correlation coefficient between EV/NPV and the Fraser Institute Investment Attractiveness Index becomes much stronger, at 0.53 (cf +0.34 for the broader sample) for companies at BFS stage of development:

Exhibit 215: Company EV as percent of attributable project NPV (%) vs Fraser Institute Mining Investment Attractiveness Index score for projects at BFS level only, 8% sample



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

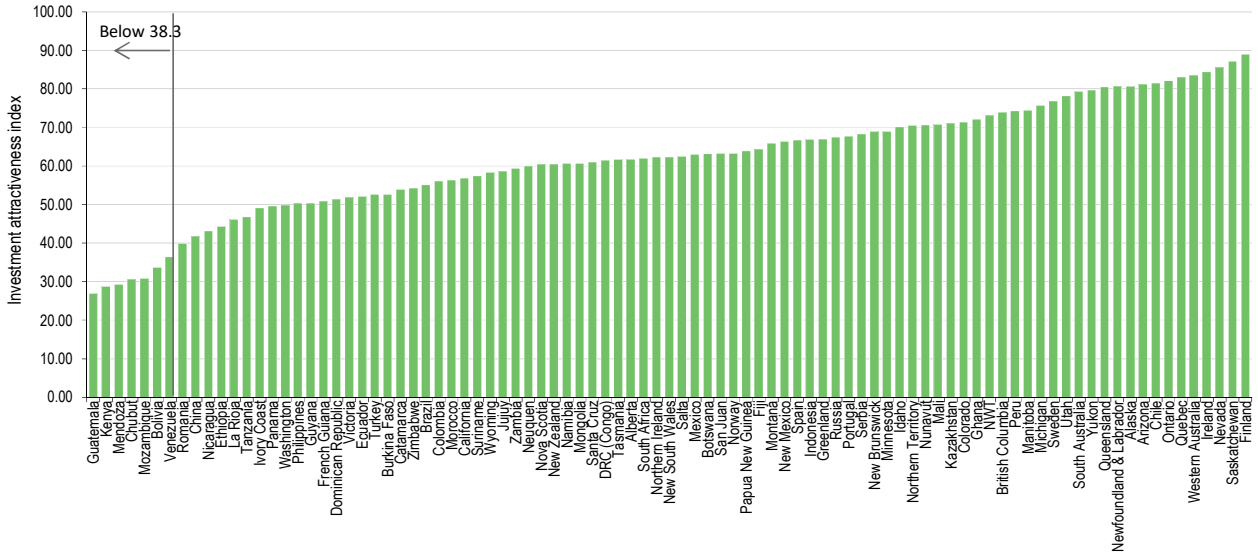
Exhibit 216: Company EV as percent of attributable project NPV (%) vs Fraser Institute Mining Investment Attractiveness Index score for projects at BFS level only, whole sample



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

In this case, the gradient of the line of best fit for companies with projects at BFS level (excluding outliers) is such that it implies that a company in a jurisdiction with a Fraser Institute Investment Attractiveness Index score of 38.3 (cf 40.8 for the whole sample) would have an EV of zero. This encompasses the bottom seven jurisdictions (cf eight previously) in the Fraser Institute's 2017 survey (published in February 2018) and puts Romania on the other side of the cut-off line:

Exhibit 217: Fraser Institute Investment Attractiveness Index, 2017



Source: Fraser Institute, Edison Investment Research

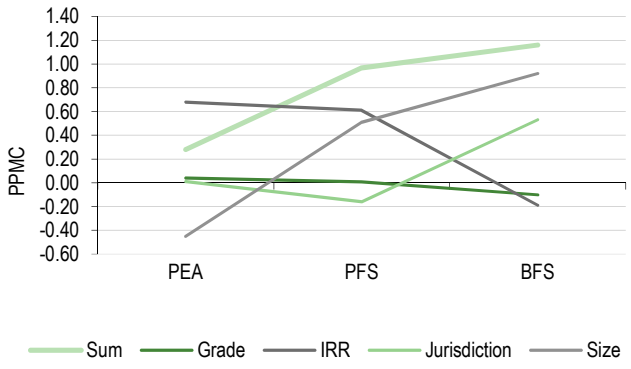
Note that neither of these investability cut-offs is dissimilar to the one calculated by us in the section on NonSuch Gold (see pages 72–74) via an entirely different method. In conclusion therefore, we can certainly reiterate that the country in which the project is located becomes significantly more important to a company's valuation as its project progresses from PEA stage to BFS stage.

Conclusions

Owing to a number of constraints, we were unable to conduct studies of the effect of a project's size or grade on a company's valuation for the standardised 8% sample group. In the light of the two studies performed for IRR and jurisdiction however, we have decided to modify our prior conclusions to those of the 8% sample for jurisdiction (as measured by the Fraser Institute's index of Investment Attractiveness), but not for IRR. While the relationship between both might be expected to be better for the 'purer' sample, both were also subject to the vicissitudes of working with a smaller sample size. In the event, the evolving correlation coefficient between jurisdiction and company valuation made more sense for the 8% sample than for the broader sample (in the sense that there was no effect at PEA stage, rather than a negative effect). By contrast, it was difficult to explain the 'rebound' in the effect of IRR on company valuations in the 8% sample as opposed to the broader sample. Nevertheless, this is something that we will continue to monitor over time.

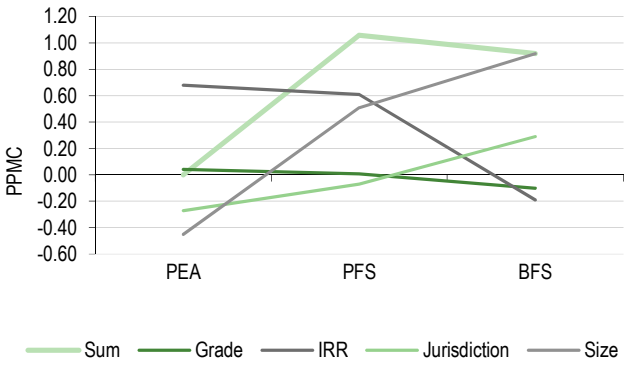
Our final graph comparing the contributions of each of the four factors hitherto considered (as determined by their correlation coefficients) to the valuations of companies at various stages of development is therefore as follows:

Exhibit 218: Graph of PPMC vs stage of development for four factors influencing valuation, 2018 (final)



Source: Edison Investment Research. Note: PPMC = Pearson product moment coefficient.

Exhibit 219: Graph of PPMC vs stage of development for four factors influencing valuation, 2018



Source: Edison Investment Research. Note: PPMC = Pearson product moment coefficient.

In comparing 2018's results with those of 2017, the main features are:

- As in 2017, IRRs remain very important at early-stage, PEA level projects, but become less so as the project is developed through to BFS.
- Jurisdiction has become more important to company valuations at BFS stage in 2018 than in 2017.
- Unlike in 2017, project size appears to be very important in contributing to valuations for companies at BFS stage.
- Interestingly, as in 2017, project resource size actually appears to detract from companies' valuations at early stages of development.
- In contrast to 2017, investors in 2018 appear to regard grade as much less important in contributing towards a company's valuation. This could be an anomaly or, as discussed above, this could be regarded as evidence that investors are moving away from the erstwhile mantra of 'grade, grade, grade'. From a statistical perspective, it certainly remains the case that there is an extremely poor relationship between grade and IRR and this is perhaps also evidence that investors are becoming more nuanced in their appreciation of the contribution of grade (within the context of other factors) towards overall investment returns to equity holders.

Qualitatively, we posit 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. The above studies encompass 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 we have identified, but not yet analysed in this statistical manner – ie engineering, metallurgy or, in particular, management. In our subjective opinion, we believe that it is likely that it is the last of these (ie management) that is responsible for a disproportionate valuation relative to the tangible and financial characteristics of a project. That being the case, considering the graphs above (Exhibits 218 and 219), this factor (ie management) could therefore be said to largely occupy the difference between the sum of the four factors so far considered and one. In 2017 therefore, at PEA and PFS stage, the valuation of a company could (apparently) be explained almost exclusively in terms of its IRR and its grade. It was only later, at BFS stage, that other factors (eg management, in particular) could be considered as becoming material in determining a company's valuation. In 2018 by contrast, the EV of a company at PFS and/or BFS stage can (apparently) be explained almost exclusively in terms of its IRR and size and it is only at earlier (ie PEA) stage that the contribution of management may be considered as material or significant in contributing to its valuation.

The 8% sample's Parthian shot?

In keeping with the rest of this report, we have also performed a simultaneous multiple regression analysis between the EVs of the companies included in the EV/NPV analysis and the four factors that are presumed to influence their valuations, namely sovereign risk (as measured by the Fraser Institute), project IRR, project NPV and the type of study performed for the 8% sample. Note that for a sample group in which all of the discount rates are the same (ie 8%), it makes no sense to include this in the analysis and hence there are four factors, where before there were five. In this case, the formula for the best-fit line (in US$m) derived via such an analysis is as follows:

EV = -60.1 + (1.0 × Fraser) + (0.6 × IRR) + (0.04 × NPV in millions) − (1.1 × study type)

This compares with our previous result, for the whole sample of:

EV = 264.9 + (0.09 × Fraser) + (0.5 × IRR) + (0.04 × NPV in millions) − (2.4 × study type) − (30.8 × discount rate)

The similarities of the factors relating to IRR and NPV are very noticeable. Without going into the details unnecessarily, suffice it to say that there is a good level of confidence surrounding the factors shown relating to the project NPV and a degree of confidence surrounding the factors relating to IRR and the Fraser Institute.

The reduction in the value of the 'intercept' is also striking and reflects the absence of an offsetting factor to apply to the discount rate of the project in question.

A number of features of the analysis are otherwise apparent:

- In this case, improving a study from PEA to PFS level would reduce a company's EV by US$1.1m (cf US$2.4m), on average – which is consistent with our earlier findings of a valuation trough at PFS stage, but not beyond that to BFS level.
- Every US$1m added to a company's project's NPV will add, on average, US$0.04m to its EV.
- Every percentage point that is added to a company's project's IRR will add, on average, US$0.6m to its EV.
- Every point by which a country increases its Fraser Index score of Investment Attractiveness will increase the EVs of the explorers operating within its borders by US$1.0m (NB this is materially more than the US$0.09m by which it increases values in the equation derived from the whole sample).

Finally, if a wholly 'average' company is considered, with 100% ownership of a project with an NPV of US$659.3m (at an 8% discount rate, see Exhibit 189), an IRR of 41.4%, operating in a jurisdiction with an average Fraser Institute Investment Attractiveness rating of 61.97 (roughly the equivalent of South Africa in the latest survey) and at PFS stage, then the implied EV of the company, as derived using the above equation, would be US$50.8m, or 7.7% of the NPV of the project. This compares with our earlier observation that companies at PFS stage in the 8% sample trade, on average, at 7.7% of the attributable NPV of their project if statistical outliers are excluded.

As before, readers are invited to come to their own conclusions regarding the veracity and accuracy of the equation within the context of this result. In our opinion, it seems (surprisingly) accurate.

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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