AN ECONOMIC ASSESSMENT OF THE EXPLORATION INCENTIVE SCHEME: 10 YEARS FROM 2009 TO 2020

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Geological Survey of Western Australia

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Cover image: Reverse circulation drilling project in the South West Terrane, Yilgarn Craton, north of Perth

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The Exploration Incentive Scheme

An economic assessment of the impact of the Exploration Incentive Scheme: 10 years from 2009 to 2020

The Exploration Incentive Scheme

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The role of the mining sector in Western Australia

Globally, Western Australia is recognised as one of the world's most prospective jurisdictions for mineral exploration, and in the most widely used industry benchmarking survey Western Australia is consistently ranked as either the top global jurisdiction for mining, or very near the top.

Market failure issues in the market for greenfield exploration

Externalities are present in the private sector greenfield exploration market and this results in underinvestment, relative to the socially optimal level of greenfield exploration investment, which in turn impacts discovery rates. Government provision of pre-competitive geoscience information and subsidies to support greenfield exploration are well established methods of correcting the exploration externality.

The Exploration Incentive Scheme

The Exploration Incentive Scheme (EIS) has operated since 2009, and is focused on correcting the greenfield exploration externality through: direct co-investment to support new drilling activity in underexplored areas; provision of new pre-competitive scientific information relevant to the development of resource exploration campaigns in new areas; and supporting additional research and development activities.

Exploration investment stimulus

Modelling found that $1 million of investment in the EIS generates $25 million in additional private sector exploration activity, on average, in the long-run. This central estimate is less than previous estimates, but within the uncertainty bounds of previously reported estimates. Much of the additional investment is sourced from outside Western Australia, and the out of State investment represents a net contribution to Gross State Product.

Future additional discoveries

With additional exploration activity, there are additional resource discoveries. A small number of these mineral discoveries become commercial mines. In Western Australia, successful discoveries can transition into very large mines, by global standards.

Expected value framework

Using an expected value framework it is possible to calculate the expected net present value from additional exploration activity, and the expected additional impact of future mines. The expected impacts, per dollar invested, in net present value terms, and the associated 95% Confidence Intervals (95% CI) are:

Additional economic activity

- exploration impact: $20.2 (95% CI $16.4 to $23.9)
- construction activity impact: $7.6 (95% CI $3.7 to $12.0)
- production wealth impact: $14.0 (95% CI $5.1 to $25.0)
- royalties and taxes $9.9 (95% CI $4.8M to $17.4M).

The EIS net benefit to Western Australia is large

Not all funds invested in exploration activity are new funds to Western Australia; and some private sector wealth created through the establishment of new mines flows to shareholders that reside outside Western Australia. Adjusting for these factors, **the central estimate for the total return to Western Australia per dollar invested in the EIS is $31** (95% CI $18.5 to $44.8). This estimate is slightly higher than previous estimates, but within the uncertainty bounds of previously reported estimates. Relative to earlier estimates the higher return is in part due to a higher gold price assumption, relative to those previously assumed, and a more precise estimate of the exploration response to EIS spending, that allowed additional upside scenarios to be considered.

The expected net present value return to Western Australia, per million dollars invested in the EIS, includes:

Additional economic activity

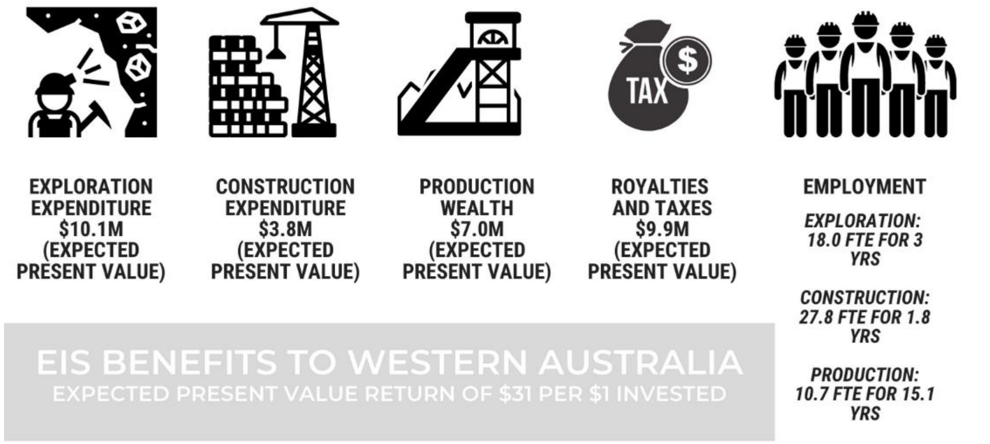
- exploration impact: $10.1M (95% CI $6.3M to $13.8M)
- construction activity impact: $3.8M (95% CI $1.8M to $6.0M)
- production wealth impact: $7.0M (95% CI $2.5M to $12.5M)
- royalties and taxes: $9.9M (95% CI $4.8M to $17.4M).

Employment impact

The expected Full-Time Equivalent (FTE) employment impacts, per million dollars invested in the EIS are:

- 18.0 FTE, for 3.0 years, as the exploration impact
- 27.8 FTE for Fu1.8 years, as the mine construction phase impact, and
- 10.7 FTE for 15.1 years, as the operating mine phase impact.

Expected return to Western Australia per $1M invested in the EIS



On-ground evidence

The modelling results are also consistent with the on-the-ground evidence of greenfield exploration campaigns supported by the EIS resulting in: new operating mines that have delivered substantial new construction activity, created substantial production wealth, and provided the government with income from royalty and tax payments; and future highly prospective developments where there are exploration companies currently transitioning to operating mine companies.

Key findings

Funding for the EIS at the current level provides a large net benefit to the Western Australian community as a whole, and also to the Government of Western Australia, narrowly defined as the return via mineral royalties and pay-roll tax. This conclusion is consistent with previous analysis of the return to the Exploration Incentive Scheme (ACIL Allen 2015), and analysis of similar programs in other jurisdictions.

1 Introduction

This report presents an evaluation of the economic impact of the Exploration Incentive Scheme (EIS). The report is the second economic impact assessment of the EIS, and follows the assessment structure established in the first report (ACIL Allen 2015); but makes use of the additional data that has become available since the first report was published.

The Exploration Incentive Scheme began as a Royalties for Regions initiative in 2009, but since July 2019 the program has been funded from Mining Tenement Rent revenue. The scheme objective is to stimulate private sector exploration activity that would not otherwise have been undertaken, in underexplored areas of Western Australia. The program is managed by the Geological Survey of Western Australia (GSWA) in the Department of Mines, Industry Regulation and Safety, and since 2009 the investment in the scheme has been over $160M. Current government policy has set funding for the EIS under normal economic conditions at $10M per annum. Additional funding has been approved for 2020-21 as part of the Government of Western Australia response to the COVID-19 pandemic.

The specific EIS sub-programs have evolved through time, but the broad focus of funded activities has been consistent and has been to support new exploration activity in underexplored areas (which includes both at depth and spatially) through the provision of pre-competitive geo-science information and direct support for drilling activities; and supporting additional research and development activities (see ECS (2019) for a summary of specific program activities).

The factors identified as contributing to the extent of private sector investment to find new resources include: (i) availability of geological information; (ii) state of technology; (iii) fiscal incentives; (iv) economic feasibility; and (v) industry perceptions of government credibility and sovereign risk (Gleb et al. 2012, p. 6). The EIS activities are well aligned with these factors.

That government investment in EIS type activities can result in a strong private sector exploration response is clear (Duke 2010). The provision of pre-competitive geoscience information opens up new areas of the State for exploration, and the provision of pre-competitive geoscience information is non-rival in consumption. This means that each new data release or data platform improvement can stimulate new exploration activity at multiple firms. The new information provided can be used by large international companies, and so result in an increased budget allocation to exploration activities in Western Australia, which due to the provision of this information has become relatively more attractive; as well as stimulate the creation of new start-up ventures. The extent of the gain is then moderated through the general mineral potential of the jurisdiction, economic and environmental regulation, and the legal framework around property rights.

The receipt of co-funding for drilling has several benefits. First, it directly lowers the marginal cost of drilling. This leads to a direct increase in the number of metres drilled. The receipt of a grant also acts as a form of third-party quality certification for projects that allows firms to raise additional private sector funds for new exploration. The additional funds raised from the private sector, which are typically many multiples of the value of the grant, are then invested in additional exploration activity. Support for this argument is developed in Fogarty and Sagerer (2016).

The existence of systematic funding rounds to support high risk exploration activity that are independent of the business cycle also decreases the probability of an exploration firm with solid fundamental prospects winding-up due to a temporary lack of funding, which might occur when prevailing market sentiment is especially negative. This potential funding bridge works to directly increase the probability of a successful campaign to investigate a target resource, conditional on the prospects being positive. Further, the existence of market condition independent funding sources works to decreases overall funding volatility, and this in turn improves the relative perception of Western Australia as a jurisdiction that has a favourable environment for mineral exploration activity, and hence increases the probability of choosing Western Australia as a jurisdiction for exploration.

Finally, the requirement to provide core samples to the State government from co-funded drilling campaigns ensures the continuing development of a resource database that is available to facilitate further research and understanding of the mineral resource distribution in Western Australia. The value of the database may only become fully realised with future technology developments, so again, one round of investment may trigger many subsequent investment rounds when technology changes.

The EIS also directly supports research activity, research training, and combined government plus research institute collaborations. The literature provides strong evidence that the financial return to government from investment in research and development is high: with an internal rate of return of around 10% (Salter and Martin, 2001; Hurley et al., 2014).

The additional exploration spending stimulated due to the EIS creates additional net benefits for Western Australia. If the funding for this additional exploration activity is sourced from within Western Australia the marginal difference between the economic impact of general consumption spending and exploration spending represents a net gain to economic activity in Western Australia. This effect is, however, likely to be small.

If the funding for additional exploration activity is sourced from outside Western Australia, the full value of this induced spending represents a net gain to economic activity in Western Australia. This can be thought of as the short-run direct impact of the program, and while these impacts can be substantial, in terms of an increase in Gross State Product (GSP), the flow of funds returning to the State government from this spending may be modest.

The long-run impact of the EIS is the wealth created due to discoveries induced by the program, that ultimately transition to commercial mines. The return to the State Government is through pay-roll tax and royalty payments from commercially operating mines, and these payments can be large. For example, in FY2020r oyalty income in Western Australia was $8.5B and is forecast to be similar in FY2021. (Government of Western Australia 2020). The return to the private sector providers of capital for exploration, from the successful development of a mine, can be many times larger than the direct exploration attraction impact, and the contribution of a mine, in terms of GSP, can be substantial.

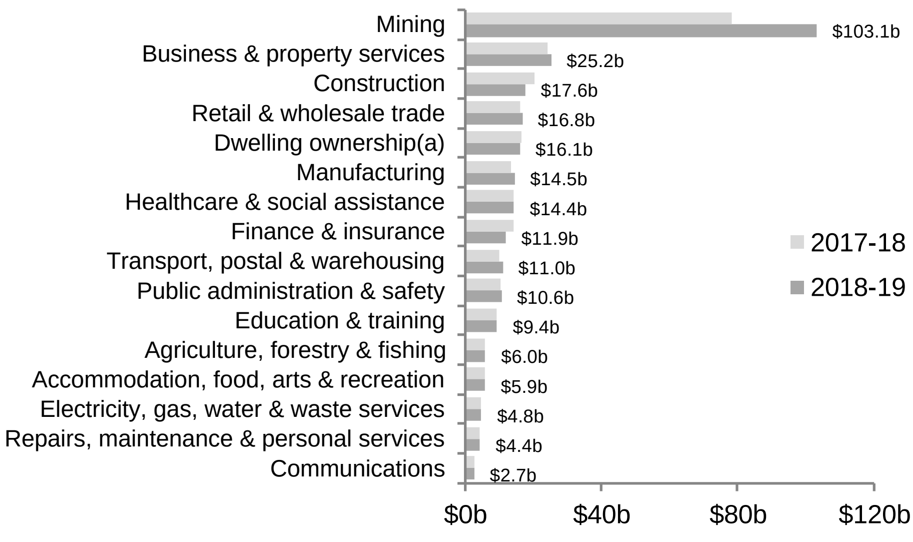
1.1 Exploration and mining in WA

Western Australia is renowned as one of the most prospective geological environments for mining and mineral exploration in the world. For example, the *Fraser Institute* publishes an annual survey of industry perceptions of jurisdictions, and Western Australia is consistently ranked as one of the top global jurisdictions for mining. In terms of the combined measure of the policy environment for mining and mineral exploration potential of the region, in the global rankings Western Australia was ranked: 4th in 2020, 1st in 2019, 2nd in 2018, 5th in 2017, 3rd in 2016, 1st in 2015, and 4th in 2014 (Fraser Institute, various years).

Other Australian jurisdictions are also well regulated and have good mineral potential, but over the past decade, on average, Western Australia has accounted for 59% of the non-petroleum mineral exploration expenditure in Australia, which for decade to December 2020 has average $1.5B per annum (ABS, 2020a).

That Western Australia is a highly favourable environment for mining activity is also evidenced through the size of the mining sector in Western Australia. For the year ending June 2019, Western Australia's Gross State Product (GSP) was $285.6B; and the mining sector represented 36% of this value (Figure 1). The relative scale of the mining sector can be seen by noting that in Western Australia the Manufacturing sector accounted for 5% of GSP; and the Agriculture, Forestry and Fishing sector accounted for 2% of GSP.

Figure 1: WA Industry sector Gross Value Added: 2018–19 and 2017–18



Source: WA Economic Profile October 2020

That mining provides much wealth for Western Australia does not justify government intervention programs such as the EIS: that provide direct and indirect subsidies to support private sector activities. Well-functioning markets are able to ensure the efficient allocation of resources to competing uses. It is generally only when an externality issue arises, or the good in question has non-excludability and/or non-rivalry in consumption aspects that government actions have the potential to improve outcomes.

As noted above, pre-competitive geoscience information is non-rivalrous in consumption. This property provides a clear theoretical basis for those EIS activities that are directly related to the provision of pre-competitive geoscience information; and this market failure issue is acknowledged by the Productivity Commission (Productivity Commission 2013).

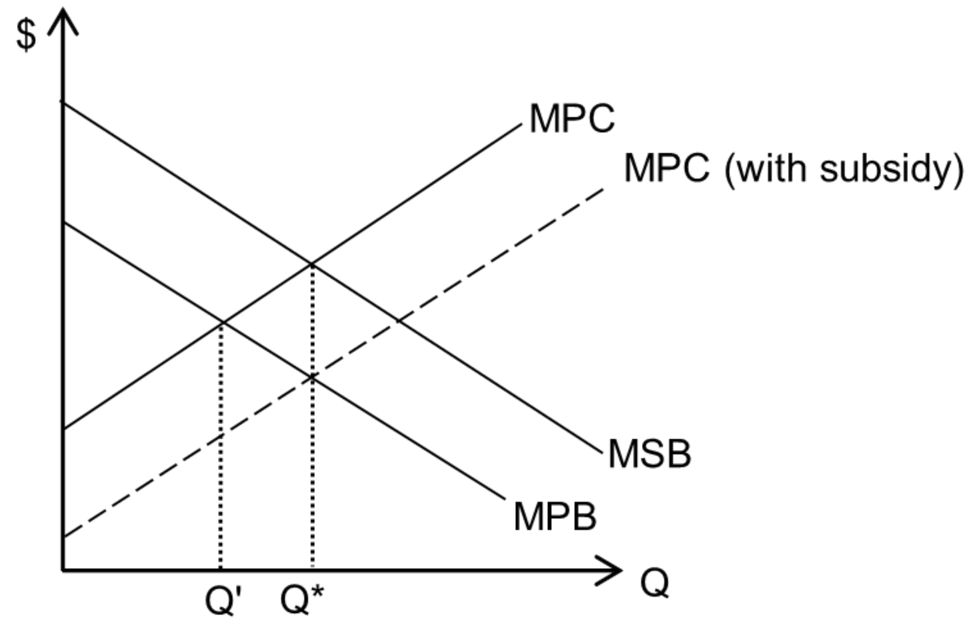
In addition to the issue of non-rivalry in the use of pre-competitive geoscience information, there is also an information externality associated with drilling campaigns that leads to underinvestment in greenfield exploration. This issue has long been recognised and provides a sound theoretical basis for government intervention to support private sector exploration activity.

Specifically, the outcome of any given exploration drilling program provides valuable information about the probability of success of future exploration drilling programs in regions with similar geological conditions. Such locations may or may not be spatially close to the location of the specific current exploration campaign. This information 'spillover' leads to underinvestment in exploration, in a completely free market.

In a pure free market scenario, exploration takes place up to the point where the expected marginal benefit is equal to the expected marginal cost. As some of the exploration campaign benefit accrues to external parties, the marginal benefit to the funder of the drilling campaign is less than the total marginal benefit, and there is underinvestment in exploration. The private marginal benefit is less than the total benefit. Further, there is a direct incentive for any given potential funder of a drilling campaign to wait and not explore until someone else first undertakes a drilling campaign.

The issue has been set out in the work of Nobel Laureate Joseph Stiglitz, where a proposed solution identified was for government to provide subsidies or tax incentives for greenfield drilling far from other drill holes (Stiglitz 1975). Such subsidies work to lower the cost of an exploration program such that the socially optimal level of exploration is achieved. The issue is illustrated in Figure 2, which shows that when the Marginal Social Benefit (MSB) is greater than the Marginal Private Benefit (MPB), the equilibrium level of exploration is Q', and this is less than the optimal level of exploration Q*. The provision of drilling subsidies for greenfield exploration, and the provision of pre-competitive geoscience information both work to lower the Marginal Private Cost (MPC) of the drilling campaign, and if the subsidy is set at the appropriate level, it is possible to reach Q*.

Figure 2: Resolving the exploration externality through EIS type investments



Note: MPC = Marginal Private Cost; MPB = Marginal Private Benefit; and MSB = Marginal Social Benefit; The distance Q* - Q' = the shortfall in the level of exploration, relative to the socially optimal level.

1.2 Key points summary

The activities funded as part of the EIS fit within a clear, sound, economic framework. The EIS program of activities are targeted at specific, widely acknowledged market failure issues: pre-competitive geoscience; greenfield exploration; and support for basic research and development. Due to the importance of the mining sector to the economy of Western Australia — as evidenced through the large revenue stream provided by Royalties — addressing these market failure issues have the potential to provide a large net benefit to the State.

1.3 Report structure

The evaluation structure in this report has been designed to be consistent with the approach used in ACIL Allen (2015) and proceeds as follows:

- Stage 1, detailed in Chapter 2 involved modelling the relationship between EIS expenditure and private sector exploration activity
- Stage 2, as detailed in Chapter 3 involved using the Stage 1 outputs to model the relationship between exploration activity and expected commercial mine discoveries
- Stage 3, as detailed in Chapter 4, involved combining the Stage 1 and Stage 2 information to: (i) provide estimates of the net benefit to Western Australia due to the EIS; (ii) explore the sensitivity of the main findings to different model assumptions; and (iii) provide a reconciliation of the current results to previous findings

- Stage 4, as detailed in Chapter 5, involved using case study example information and other evidence as independent sources of evidence to validate the empirical modelling.

In terms of reporting, in addition to central case estimates, the report focuses on presenting probability distributions to provide a measure of uncertainty around both central case results and the sensitivity results.

2 Exploration investment impact

This chapter represents the Stage 1 analysis and: (i) provides a summary of the previous approaches that have been used to model the relationship between EIS/geoscience spending and private sector exploration activity, including the strengths and weaknesses of these approaches; (ii) outlines some alternative approaches to modelling the relationship between EIS spending and private sector exploration activity, including the strengths and weaknesses of the alternatives; (iii) provides a summary of the data used to estimate the relationship between EIS spending and private sector exploration activity; and (iv) presents modelling results.

2.1 Previous modelling strategies

In ACIL Allen (2015) an Autoregressive Distributed Lag (ADL) modelling framework is used to estimate the relationship between EIS spending and exploration spending. Additionally, the relationship between overall Government of Western Australia investment in geoscience and exploration spending is investigated in Fogarty and Sagerer (2016) using a similar modelling strategy.

Here the focus is on the ACIL Allen (2015) model, which can be understood as follows: Let: Q_t denote the actual level of exploration activity at time t; E_t, denote the actual level of EIS investment at time t; and P_{1t}, P_{2t} P_{3t} denote a set of three relevant commodity prices, at time t. With this notation the estimated model can be written as:

$$Q_t \ = \alpha + \beta_1 E_t + \beta_2 E_{t-1} + \beta_3 Q_{t-1} + \beta_4 P_{1t} + \beta_5 P_{2t} + \beta_6 P_{3t} + e_t, \qquad (1)$$

where the β_i are parameters to be estimated, and e_t is a zero mean error term. In equation (1) the short run (current period) effect of EIS spending is given by β_1. As detailed in the appendix, the long run effect is found by substituting long run equilibrium values into equation (1), which after rearranging generates the expression $(\beta_1 + \beta_2)/(1 - \beta_3)$ as describing the change in the equilibrium level of private sector exploration activity following a one unit change in EIS spending. This change defines the long-run impact of EIS spending on exploration activity.

The model can be estimated in terms of logs, where the estimated coefficients are interpreted as elasticities, or in levels, where the values can be interpreted as multipliers. The strength of this modelling approach is the relatively sophisticated treatment of dynamics (through the use of lagged values for both private sector exploration activity and EIS spending as covariates); and the use of several different commodity prices to capture market conditions. The cost of using this modelling approach is that it introduces multicollinearity into the model, and through the inclusion of many explanatory variable reduces the effective sample size. This in turn leads to estimates that are unbiased, but imprecise.

The ACIL Allen (2015) report focused on models in levels, where standard error information was derived via the delta method. The mean estimate for the long run EIS impact was $178 per dollar invested, with a 95% Confidence Interval (95% CI) of $20 to $336.

Similarly, in Fogarty and Sagerer (2016), which uses a similar modelling approach to ACIL Allen (2015), the mean estimate for the impact of general geoscience spending on exploration activity is large ($130 per dollar invested), and the 95% CI wide: $5 to $254 per dollar invested.

Faced with significant estimate uncertainty, both previous studies take a conservative approach and use the 95% confidence interval lower bound estimate as the estimate of the long run response of exploration spending stimulated for every $1 of government investment in either the EIS (ACIL Allen 2015) or geoscience (Fogarty and Sagerer 2016).

When faced with estimate uncertainty such an approach is a valid strategy, but results in a conservative estimate of impacts.

2.2 Alternative modelling strategies

The existing literature provides strong evidence of a positive relationship between government investment in geoscience and private sector exploration investment; and that dynamics are an important feature. The main limitation of the existing literature is that estimates are imprecise, and this is primarily caused by multicollinearity. The source of the multicollinearity is the inclusion of correlated variables as regression model covariates. The correlated variables are: commodity prices at a given point in time; and current and past period EIS expenditure through time.

The estimate imprecision issue can be addressed, at a cost of a less complete description of dynamics, and a less nuanced treatment of market conditions variables.

Specifically, the partial adjustment model is a specific (restricted) type of ADL model that removes the need to include lagged values of EIS expenditure as a covariate, but still allows both short run and long run effects to be estimated through the inclusion of lagged exploration expenditure as a covariate. With this model the core elements of a dynamic model are maintained, but multicollinearity issues are decreased.

Additionally, rather than including values for multiple separate commodity price series to capture market conditions, Principle Component Analysis (PCA) can be used to generate a single composite market conditions variable, defined as the first principle component from analysis of the relevant price series. This approach allows for a substantial reduction in multicollinearity issues, and also increases the model degrees of freedom.

Formally, the trade-off across approaches is described as a variance-bias trade-off. In practice, for this application, the cost is a slightly less precise description of overall market conditions via the covariates that controls for market conditions, and that the market conditions variable does not have a natural interpretation. For example, when prices are included directly in the model the estimated coefficients describe directly the impact of prices on exploration activity. With the use of a principle component covariate such a direct interpretation is not possible. With mean centred data the principle component covariate can describe positive and negative market conditions, and the relative intensity of market conditions, but there is no direct meaning to the coefficient estimate attached to the variable in the regression model.

Within the specific context of trying to 'control' for the impact of market conditions, rather than directly model the impact of commodity prices, the benefits of the PCA approach can substantially outweigh the costs.

Finally, rather than rely on a frequentist estimation strategy, a Bayesian approach can be used, where priors that reflect known information such as: (i) the relationship between government investment in geoscience and exploration investment is likely to be positive; (ii) the relationship between commodity prices and exploration investment is likely to be positive; (iii) the long run response of the private sector to EIS spending is likely to be greater than the short run response can be used.

Arguments can be made in favour of both Bayesian and Frequentist methods, but the case for Bayesian methods is made in Gelman, et al. (2013), and as computer power has increased Bayesian methods have increased in popularity.

2.3 Model structure and inputs

The three strategies to mitigate against estimate imprecision described in the previous section have been implemented. The details are described here.

2.3.1 Principle component analysis

The PCA relied on Kassambara and Mundt (2020) to implement the relevant data decompositions. The inputs were AUD gold, nickel, and iron ore prices from FY2004 through FY2020. Maximum quarterly prices were used for each commodity. Data were downloaded from Bloomberg, and for iron ore the reported price series for Hebei was selected and merged with historical government data.

2.3.2 Regression model structure

The model estimated can be written as:

$$Q_t = \alpha + \beta_1 E_t + \beta_2 G_t + \beta_3 M_t + \beta_4 Q_{t-1} + e_t, \tag{2}$$

where the β_i are again parameters to be estimated; E_t, Q_t, and e_t are as previously defined; G_t denotes general geoscience and related service expenditure; and M_t, denotes market conditions, as measured by the first principle component from analysis of the iron ore, gold, and nickel price.

Similar to equation (1), in equation (2), the short run (current period) effect of EIS spending is given by β_1, but the long run effect is now found as $(\beta_1)/(1-\beta_4)$. With this model form, this expression defines the long run impact of EIS spending on exploration activity in Western Australia. A complete explanation of the way the dynamics work, and why this expression defines the long-run relationship is provided in the Appendix material.

2.3.3 Regression model inputs

The response variable is non-petroleum exploration expenditure in Western Australia, as reported in ABS catalogue 8412.0. The model covariates are: (i) EIS expenditure and other relevant GSWA expenditure, as separate covariates, as provided by the Department; (ii) the first principle component from the commodity price model to capture market conditions; and (iii) lagged non-petroleum exploration expenditure, to capture dynamics

As part of the model structure it is necessary to make starting distributional assumptions for each component of the model. As these distribution assumptions are made prior to model estimation they are referred to as model priors. The prior for the intercept (α) on the mean centred data is a normal distribution with location parameter (mean) zero and scale (standard deviation) parameter 2.5 times the standard deviation of the response variable (non-petroleum exploration expenditure in Western Australia). The priors for β_1 through β_3, are characterised by a Laplace distribution with location parameter ten, and scale parameter two. The prior for the speed of adjustment parameter (β_4) is a Laplace distribution with location parameter one-half, and scale parameter two.[1] The prior for the model error standard deviation parameter is an exponential distribution with the rate parameter set at the reciprocal of the response variable standard deviation.

With Bayesian model estimation it is necessary to allow the sampling algorithm to 'warm-up'. The warm-up samples are referred to as the burn-in. Samples from the burn-in are discarded. It is also possible for the sampling algorithm to get stuck and not sample the complete distribution appropriately. One way to identify whether this is a problem is to run the sampling algorithm for many iterations, and run it multiple times (each run is called a chain) to check for consistency in results. The post burn-in Markov Chain Monte Carlo (MCMC) chain length is set at 1,000, and four chains are used. Agreement across the between- and within-chain estimates is measured via the $\hat{R}$ diagnostic, where samples are only used if $\hat{R} < 1.05$. This approach is recognised as generating reliable estimates for parameter distributions. Model estimation relied on Goodrich et al. (2020).

[1] As detailed in the appendix, the speed of adjustment parameter should lie between zero and one. As the speed of adjustment parameter is central to the long run estimate, the role of the prior was investigated by revising the prior to a Laplace distribution with location parameter ten, and scale parameter two. The long run estimate was, in practical terms the same as reported in the text. This suggests there is sufficient information in the data for the prior to not dominate this effect.

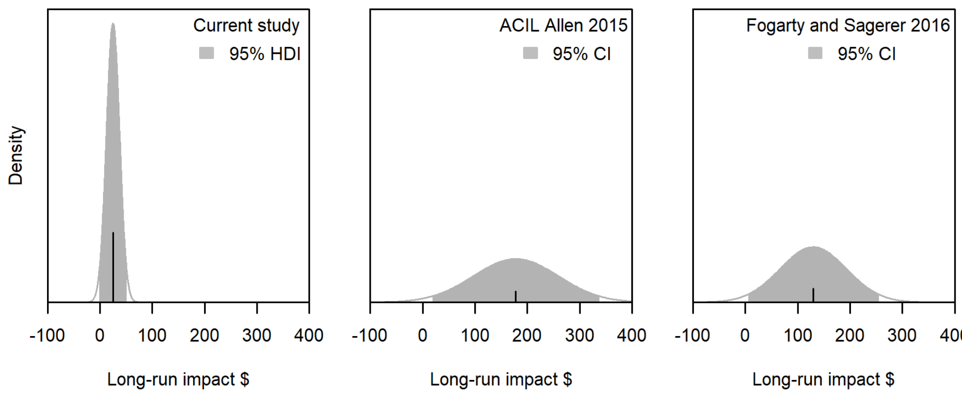
2.4 Regression model results

The implied long run impact multiplier is 24.9 (SD 12.6). This means that for every $1 investment in the EIS, in the long run an additional $25 in exploration expenditure is stimulated, on average. The median R^2 value for the model is 0.59, suggesting that despite the use of a relatively simple model to describe both dynamics and prevailing market conditions, the majority of the variation in the data is explained by the model. The speed of adjustment parameter estimate is 0.42, which says that gap between actual and target exploration expenditure shrinks by 42% each year.

There is still considerable uncertainty in the long run multiplier estimate, but relative to earlier modelling that relied on a shorter data series, estimate precision has been substantially improved. The implied posterior distribution for the current model estimate of the long run estimate is shown Figure 3, along with information on earlier estimates.

The current long run estimates are consistent with the lower end of previously reported values, but as noted above, and as can be seen in Figure 3, previous estimates were relatively imprecise. The current estimates are also broadly consistent with the summary of 19 studies looking at the extent of new exploration expenditure stimulated by government exploration initiative programs reported in Duke (2010). In Duke (2010) the mean increase in private sector exploration for each dollar of government investment is 6.2, and the maximum response value reported is a $19 increase in exploration for every $1 of government investment. Given that in global rankings Western Australia is consistently ranked as one of the best places for mining and exploration, it is reasonable to expect that the response in Western Australia would be consistent with the upper end of previously reported estimates.

Figure 3: Comparison of current and previous long-run impact estimates



Note: Although the technical interpretation of the measures is different, for practical comparison purposes the 95% HDI (Highest Density Interval) from Bayesian models and the 95% CI (Confidence Interval) from Frequentist models can be viewed as comparable measures of estimate uncertainty.

Unlike previous analysis that has been concerned about estimate precision and so advocated using the 95% CI lower bound estimate as the exploration multiplier, here, the central estimate of $25 in new exploration activity stimulated, per $1 invested in the EIS, is chosen as the long run impact estimate. Additionally, we recommend plus and minus one standard deviation ($12.50) as an appropriate measure of uncertainty.

In terms of a contribution to GSP, the funds attracted to Western Australia from either interstate or overseas can be seen as a net contribution to GSP. Funds raised from within Western Australia represent a reallocation of spending from one activity (general private sector consumption) to another (exploration activity) and so do not represent a net, new contribution to GSP.

ACIL Allen (2015) assume that at most 50% of funds for exploration are sourced from within Western Australia. This is a reasonable assumption and so is maintained for this evaluation. This implies the net primary contribution to GSP in terms of new funds invested in economic activity in Western Australia is a return of around $12.5 for every $1 invested in the EIS.

3 Exploration impacts model

The evaluation of the impact of the net increase in exploration spending follows the framework introduced in ACIL Allen (2015), but extends the approach to capture additional sources of uncertainty, and presents result distributions rather than high, low, and central estimate scenarios. The central estimate from the base case modelling in this report can be compared to the central case estimate in the previous ACIL Allen report.

3.1 The logic for an expected value framework

The previous section established that EIS investment leads to additional exploration activity in Western Australia. Exploration activity is a high-risk activity. Most exploration activity does not result in the establishment of a commercial mine, and so the commercial pay-off to most exploration activity is approximately zero. A small number of drilling campaigns result in commercially exploitable discoveries, and in rare cases very large commercial discoveries are made. A firm undertaking an exploration campaign therefore incurs expenditure with certainty, for an uncertain future payoff, potentially far into the future, and the distribution is highly skewed.

The expected commercial pay-off to exploration can be understood through the analysis of the performance of 100 randomly selected Australian Stock Exchange (ASX) listed junior Australian mineral exploration companies presented in Schodde (2014). Over a ten-year period:

- 78 companies decreased in value; with 41 companies falling in value by more than 90%; and 18 falling in value by 99%.
- 22 companies increased in value; two by a factor of more than 30; two by a factor of between 15 and 10; three by a factor of between 10 and 5; nine by a factor of between 5 and 2; and the rest less than doubled in value.

The relatively high proportion of exploration companies that have increased in value over a ten-year period demonstrates that exploration activity in Australia, in general, is very successful. The highly skewed return distribution shows that although the expected return to an investment in a junior exploration company is positive, the median result for an investment in a junior exploration company is for the value of that investment to collapse by almost 90%.

Where payoffs are uncertain, it is helpful to use an expected value framework. The basic elements of the framework can be understood by considering a stylised and simplified flow of decisions for an individual exploration company that has one initial round of exploration funding. At each stage of the simplified and stylised decision process the outcome is to either proceed to the next stage or stop.

1) The firm raises money for an exploration campaign. The decision on where to conduct the campaign (Western Australia or elsewhere) has been influenced by access to pre-competitive geoscience data that allows exploration activity risk to be lowered, and/or government co-funding for drilling; local human and physical capital availability; governance and legal framework arrangements; and the general level of infrastructure and cost of doing business considerations. The campaign either takes place in either Western Australia or another jurisdiction.

2) The result of the campaign is that either a significant find is made or is not made. The probability that a significant find is made is influenced by the geological environments present in the selected area of exploration, the extent of funds raised, and the available human and physical capital. If a significant find is not made, the company ceases. If a significant find is made, the company undertakes a second, much larger funding round to conduct further drilling to prove up the resource.

3) The second drilling program establishes that the resource either has commercial potential, or does not. If the resource does not have commercial potential, the company ceases. If the deposit has commercial potential the company seeks to transition the discovery into an operating mine, of the appropriate size: small, medium, or large.

4) If market conditions (prices) are favourable, the discovery transitions to a commercial mine of the appropriate size. If market conditions are not favourable, the discovery is deemed uneconomic and the company ceases.

5) The transition to operating mine stage involves another much more substantial funding round, and these funds are used for mine construction. During this stage there are substantial construction expenditure and employment benefits delivered within regional Western Australia. Much of the funding used for the construction phase is provided from outside Western Australia and so is a net gain to the State.

6) Once the mine starts operating, the owners receive income from the profit generated on the sale of minerals, and the government receives Royalty income and pay-roll tax income.

3.2 Expected mines model structure

For consistency with previous evaluations, to derive the base case results the essential elements of the ACIL Allen (2015) structure are followed. Alternative scenarios are then explored through sensitivity analysis.

The ACIL Allen model structure can be understood as follows. The government invests $1M in the EIS and this triggers additional private sector exploration activity, which can be measured in terms of additional metres drilled. Discoveries of different mine types are made every 1.73 million metres drilled in the ACIL Allen (2015) study, and depending on market conditions a proportion of these discoveries transition to operating mines. Only when discoveries transition to operating mines is there a return to those that funded the drilling campaign, and government.

The returns are expressed in terms of Expected Net Present value terms.

ACIL Allen considered three commodity types and three mine sizes, where any given exploration campaign is not considered mineral specific: i.e. the metres drilled count equally towards the discovery of each mine type, in the relative proportion such discoveries are made. This is an appropriate assumption for the modelling approach used, and is maintained in this evaluation.

3.3 Key model assumptions

Key model assumptions relate to:

i) the exploration expenditure triggered by the EIS

ii) the all-in cost per metre drilled

iii) the distance drilled per commercial find

iv) the nature of each commercial find

v) commodity prices

vi) mining Royalty rates, and

vii) the discount rate used to convert future values into Net Present Value (NPV) equivalents.

The model assumptions and the relationship to the values used in the ACIL Allen report are detailed below.

Exploration activity triggered by the EIS

The modelling of the private sector response to EIS spending found that $1M in EIS investment stimulated a $25M private sector response, with SD $12.6. To reflect uncertainty the model assumes $1M in EIS spending triggers either $12.5M, $25.0M, or $37.5M in additional exploration investment. The high and low bounds reflect one standard deviation above and below the central estimate.

This improves upon ACIL Allen (2015), where a single value of $19.8M (in 2015 dollars) was used for the private sector investment stimulated per $1M invested in the EIS. As the value used in ACIL Allen (2015) was a lower bound estimate, it was argued that this assumption was sufficiently conservative to be confident that the modelled results would be realised. In light of the limited data availability at the time this was a valid modelling choice, but it does mean that the overall ACIL Allen (2015) are conservative estimates.

For comparison purposes, Table 1 shows the inflation adjusted ACIL Allen values and the current study values in 2020 dollar equivalents. It is important to note that the current study includes values similar to the value assumed in ACIL Allen (2015) and also more responsive and less responsive scenarios.

Table 1: Exploration activity triggered per $1 in EIS investment (2020 dollars)

ACIL Allen (2015)	Low response	Central case	High response
21.5	12.5	25.0	37.5

Note: Inflation conversion is via the RBA inflation calculator.

Drilling activity triggered by the EIS

The ACIL Allen report uses Australian Bureau of Statistics (ABS) catalogue 8412 to estimate the per meter drilling cost and using a three-year average report $382 as the per metre drilled cost (in 2015 dollars).

Analysis of the same data source for the 12-years to September 2020 suggests that the all-in cost of exploration drilling for new deposits over the past 12-years has been around $340 per metre drilled (in 2020 inflation adjusted dollars). Cost can fluctuate with the business cycle. When looked at on a quarter-by-quarter basis the standard deviation in per metre drilling costs is approximately $90. When looked at on an annual basis, the standard deviation is around $45. The kind of drilling stimulated by and/or directly supported through EIS funding is likely to be relatively remote. Reflecting this, and the variation in drilling costs through time, the central all-in drilling cost is set at $350 per metre with $275 per metre and $425 per metre used to define the high low range. The marginal cost of any drilling program will be less than this, but this value attempts to capture ancillary costs associated with exploration activity.

A comparison of the ACIL Allen inflation adjusted model value and the values used in this study is presented in Table 2. The reason for the difference in the central estimate is that real drilling costs, on average, have been lower in the years since the ACIL Allen report was completed (see Figure 4).

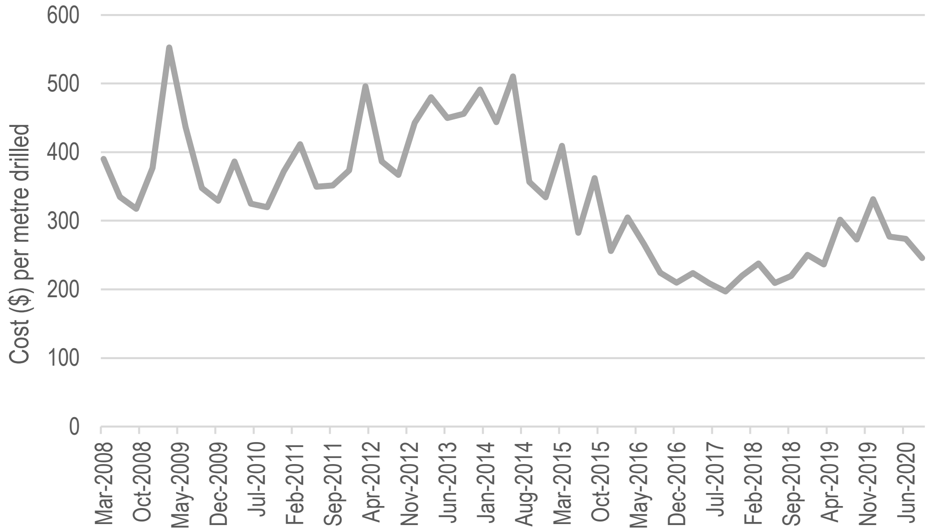
Table 2: All-in per metre drilling costs assumptions (2020 dollars)

ACIL Allen (2015)	High cost	Central case	Low cost
415	425	350	275

Note: Inflation conversion is via RBA inflation calculator.

Source: ABS catalogue 8412.

Figure 4: Evolution of exploration drilling costs (inflation adjusted 2020 dollars)



Note: Historical values inflated to current dollar equivalents using National CPI values
Source: ABS catalogue 8412

Expected discovery distribution

The distance drilled per commercial find is based on ACIL Allen (2015), and again nine types of resource discovery are the focus. Values are, however, adjusted to reflect the detail in Schodde (2019) that shows a general trend towards an increasing cost per discovery. Unlike ACIL Allen (2015), which uses a single discovery rate distribution, in this analysis three different discovery rate distributions are used. In Table 3, specific values are reported that match the way the information was reported in ACIL Allen (2015). Note that the discovery rates represent the rate of discovery to a given drilling campaign, allocated across all nine representative mine types, and not the overall rate of discovery per metres drilled.

Table 3: Metres drilled per commercial discover: (Million metres)

Mine type	ACIL Allen (2015)	Low success rate	Medium success rate	High success rate
Small Gold Mine	3.8	4.8	4.0	3.6
Medium Gold Mine	13.6	17.0	14.2	12.9
Large Gold Mine	50.9	63.6	53.4	48.3
Small Nickel Mine	15.6	19.6	16.4	14.9
Medium Nickel Mine	29.1	36.3	30.5	27.6
Large Nickel Mine	50.9	63.6	53.4	48.3
Small Iron Ore Mine	14.5	18.2	15.3	13.8
Medium Iron Ore Mine	67.8	84.8	71.2	64.4
Large Iron Ore Mine	67.8	84.8	71.2	64.4

An alternate way of expressing the detail in Table 3 is in terms of the impact on success probabilities. Using the long run exploration impact of $25, and the central case per meters drilled, Table 4 describes the long run impact of $1M in EIS investment in terms of the success probability of a find of each type. The central case discovery rate in this evaluation is slightly less than the ACIL Allen values, but the high and low cases ensure that a range of outcomes are considered.

Table 4: Impact of $1M of EIS investment on discovery probabilities

Mine type	ACIL Allen (2015)	Low success rate	Medium success rate	High success rate
Small Gold Mine	0.0188	0.0149	0.0179	0.0198
Medium Gold Mine	0.0053	0.0042	0.0050	0.0055
Large Gold Mine	0.0014	0.0011	0.0013	0.0015
Small Nickel Mine	0.0046	0.0036	0.0044	0.0048
Medium Nickel Mine	0.0025	0.0020	0.0023	0.0026
Large Nickel Mine	0.0014	0.0011	0.0013	0.0015
Small Iron Ore Mine	0.0049	0.0039	0.0047	0.0052
Medium Iron Ore Mine	0.0011	0.0008	0.0010	0.0011
Large Iron Ore Mine	0.0011	0.0008	0.0010	0.0011

Mine characteristics

The nature of each commercial find is described via a styled mine. For each mine the assumed wage is $140,000 per FTE, which is based on the ABS May 2020 Average Weekly earnings survey for the mining sector. For mine construction it is assumed that the average wage is $100,000, due a much greater variety of labour being required.

The stylised mines are consistent with those used in ACIL Allen (2015), which were calibrated to mines in Western Australia. By global standards, the large discovery mine category is a very large mine, but this is consistent with the nature of mining in Western Australia. For example, the large mine types are broadly consistent with: Boddington for gold; Ravensthorpe for nickel; and Roy Hill for iron ore. Medium and small discoveries are also relatively large mines, as they are proportional to the scale of mines in Western Australia.

As part of the sensitivity testing a scenario is considered where iron ore mines are excluded from the analysis.

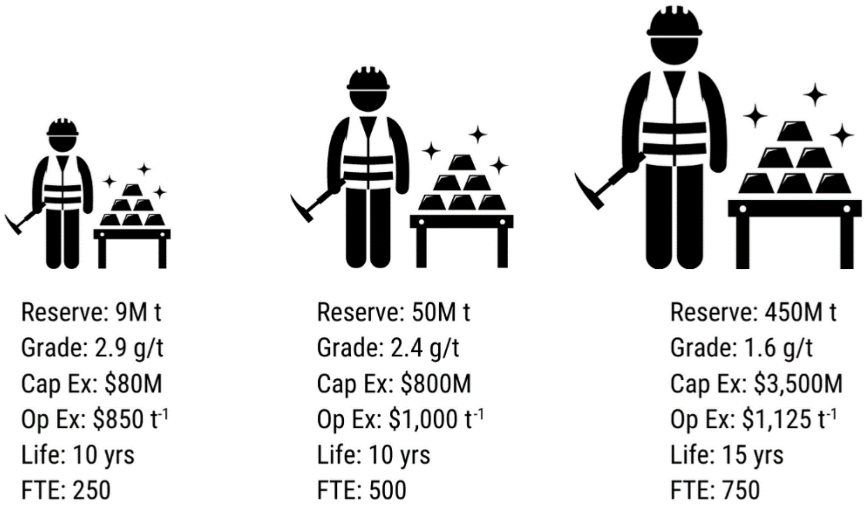
Representative gold mines

The representative small gold mine discovery has a reserve of 9M tonnes, at an average grade of 2.9 grams per tonne; a construction cost of $80M; operating expenses of $850 per tonne; 250 FTE employees, and an operating life of 10 years. The time from drilling to the start of construction is two years, construction time is 6 months, and it takes a further 6 months to reach full production.

The representative medium gold mine discovery has a reserve of 50M tonnes, at an average grade of 2.4 grams per tonne; a construction cost of $800M; operating expenses of $1,000 per tonne; 500 FTE employees, and an operating life of 10 years. The time from drilling to the start of construction is 5 years, construction time is 1.5 years, and it takes a further 6 months to reach full production.

The representative large gold mine discovery has a reserve of 450M tonnes, at an average grade of 1.6 grams per tonne; a construction cost of $3,500M; operating expenses of $1,125 per tonne; 750 FTE employees, and an operating life of 15 years. The time from drilling to the start of construction is 10 years, construction time is 2.5 years, and it takes a further year to reach full production.

Figure 5: Representative gold mines



Representative nickel mines

The representative small nickel mine discovery has a reserve of 8M tonnes, at an average grade of 1.6%; a construction cost of $80M; operating expenses of $10,000 per tonne; 100 FTE employees, and an operating life of 15 years. The time from drilling to the start of construction is 2 years, construction time is 1 year, and it takes a further 6 months to reach full production.

The representative medium nickel mine discovery has a reserve of 25M tonnes, at an average grade of 1.6%; a construction cost of $500M; operating expenses of $8,000 per tonne; 225 FTE employees, and an operating life of 15 years. The time from drilling to the start of construction is 5 years, construction time is 1.5 years, and it takes a further year to reach full production.

The representative large nickel mine discovery has a reserve of 180M tonnes, at an average grade of 0.8%; a construction cost of $2,000M; operating expenses of $18,000 per tonne; 390 FTE employees, and an operating life of 55 years. The time from drilling to the start of construction is 10 years, construction time is 4 years, and it takes a further 2 years to reach full production.

Figure 6: Representative nickel mines

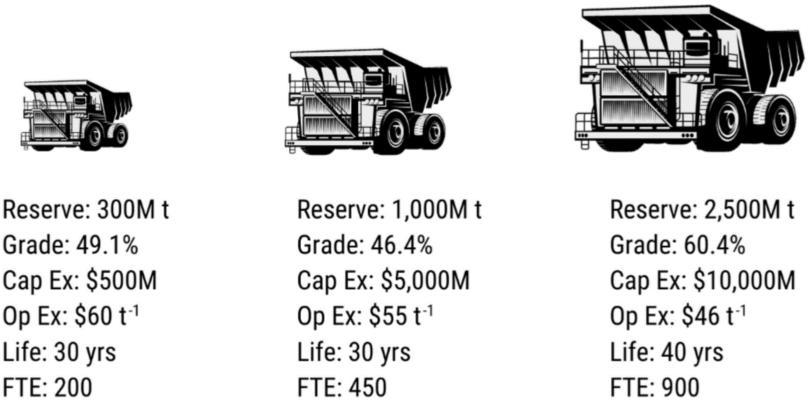
Representative iron ore mines

The representative small iron ore mine discovery has a reserve of 300M tonnes, at an average grade of 49.1%; a construction cost of $500M; operating expenses of $60 per tonne; 200 FTE employees, and an operating life of 30 years. The time from drilling to the start of construction is 5 years, construction time is 1.5 years, and it takes a further 1.5 years to reach full production.

The representative medium iron ore mine discovery has a reserve of 1,000M tonnes, at an average grade of 46.4%; a construction cost of $5,000M; operating expenses of $55 per tonne; 450 FTE employees, and an operating life of 30 years. The time from drilling to the start of construction is 7 years, construction time is 3 years, and it takes a further 2 years to reach full production.

The representative large iron ore mine discovery has a reserve of 2,500M tonnes, at an average grade of 60.4%; a construction cost of $10,000M; operating expenses of $46 per tonne; 900 FTE employees, and an operating life of 40 years. The time from drilling to the start of construction is 10 years, construction time is 5 years, and it takes a further 3 years to reach full production.

Figure 7: Representative iron ore mines



Commodity price assumptions

The price scenarios assumed as potential average prices achieved over the life of each mine are shown in Table 5, where the values in parentheses are the values in ACIL Allen (2015). The ACIL Allen report notes that the values used were agreed with the Department. The values used here have been derived from analysis of the Bloomberg price data for the past 20 years, where the objective has been to characterise average prices that might be achieved over a period of time, and not just the extremes highs and lows of the price distribution. The main difference between the two sets of values is the decrease in the nickel price assumption and the increase in the gold price assumption. The central case value for iron ore is approximately unchanged, but the range is larger in this study, relative to the values used in the ACIL Allen report.

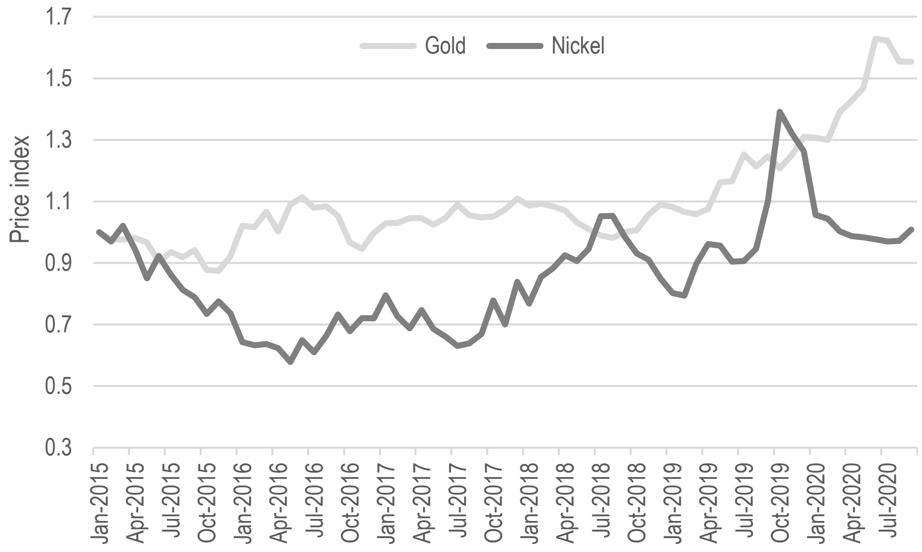
Table 5: Price assumptions per commodity reconciliation

Scenario	Nickel	Gold	Iron ore
	$AUD per T	$AUD per Oz	$AUD per T
Low	11,000 (15,000)	1,200 (1,200)	60 (65)
Central	16,500 (20,000)	1,600 (1,400)	100 (95)
High	22,500 (35,000)	2,000 (1,600)	150 (125)

Note: Iron Ore is for 62% Fe.

Source: Bloomberg price data.

Figure 8: Relative price evolution for gold and nickel since 2015 report



Note: The scale of each price series is quite different, and so each price series has been normalised to a standardised index value so that the relative change in price can be compared.

Source: Bloomberg.

Royalty rates

The royalty rates are the same for the current study and the ACIL Allen (2015) study: 2.5% for gold and nickel, and 7.5% for iron ore.

Discount rate assumption

There remains considerable debate regarding the appropriate discount rate to use when evaluating government funded programs. Infrastructure Australia has settled on three reference rates for high, low, and medium discount rates, and these rates are 10%, 7%, and 4%. These rates are broadly consistent with the range of values historically recommended by the State Government.

Use of a high discount rate does not automatically mean a conservative approach is being used. For example, in the mining sector, where there are significant end of project costs, use of a high discount rate will result in a low weight being placed on these end of project costs, and such an approach could not be considered a conservative approach to project analysis.

It is also important to note that although discount rate advice in Australia has been relatively static, this is not the case for all global jurisdictions. In the US, the required discount rate to use for evaluations of Federal Government programs is published annually. The 2020 recommended discount rate for program evaluations of the scale used in this analysis is 0.4% real (OMB 2019).

The discount rate plays an important role in the evaluation. For example, consider the stylised large mines. In each case there is a ten-year delay between when initial drilling takes place, and when construction of the mine starts; construction takes up to 5 years; and mine life is between 15 and 55 years. The large time lag between when drilling takes place, and when royalty revenue starts to flow, means the discount rate has a large impact on the NPV calculation. This is illustrated in Table 6, which shows the value of $1 in royalty income discounted to a current NPV equivalent, at time horizons relevant for a large commercial find.

The model assumes that it would be 15-years between a drilling campaign that identified a large (Tier 1) resource and when production would start to generate royalty income. At a real discount rate of 2% — which is substantially less than the 2020 cost of State government debt, and also substantially above the US government recommended discount rate — $1 of Royalty income would have an NPV of 74.3 cents; while if the discount rate was 10% this value would 23.9 cents. As can be seen from the last row of Table 6, for a large mine, that would still be operating 60 years after the initial discovery, with a high discount rate the NPV of the Royalty income is approximately zero, at the end of mine life.

Table 6: NPV of $1 at different discount rates and time horizons (cents)

	2%	4%	7%	10%
15-years from drilling	74.3	55.5	36.2	23.9
30-years from drilling	55.2	30.8	13.1	5.7
60-years from drilling	30.5	9.5	1.7	0.3

For this application we set the discount rate at 4% when evaluating the return to government, which is the same value used in ACIL Allen (2015). The impact of assuming discount rates of 2% and 7% is explored as part of the sensitivity analysis.

Project valuation for the private sector is different to that for the government sector. For the private sector there are both financing cost considerations and idiosyncratic project risk considerations. As such it is generally not appropriate to use the same discount rate for the private sector as used for the government sector. Different government and private sector discount rates are used in ACIL Allen (2015), and a literature has developed on the use of a lower discount rate for the public sector within the context of public-private projects (Grout 2007). In the context of public geoscience and exploration activity, Gildemeister et al., (2018) discuss choosing between the private sector discount rate of 10% or the government social discount rate of 6% for project evaluation. For the private sector perspective calculations, the central case relies on a real discount rate of 10%, with the impact of 8% and 12% explored as part of the sensitivity testing.

3.4 Summary exploration impacts

The model results can be separated into the private sector impact, and the return to government impact.

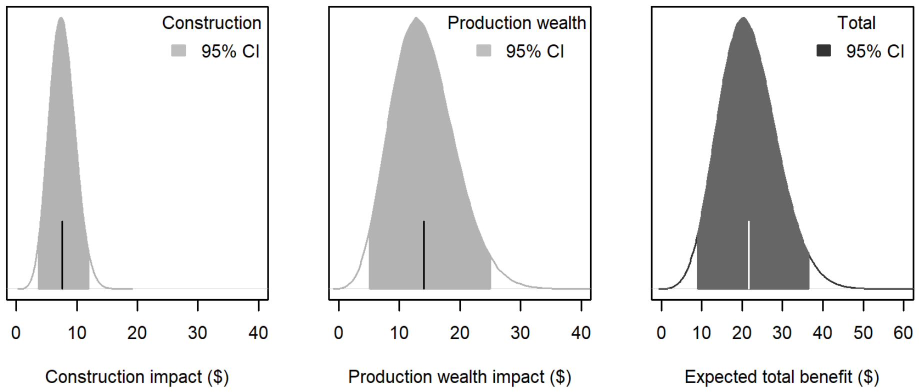
3.4.1 Private sector impacts

The private sector impacts are calculated net of taxes and royalty payments, and impacts per dollar of EIS investment, and are as follows:

- The mean NPV for construction activity associated with the mine infrastructure build stage is $7.6, with 95% CI $3.7 to $12.0

- The mean NPV for the production wealth associated with mineral production is $14.0, with 95% CI $5.1 to $25.0, and
- The mean NPV for the total private sector wealth associated with constructing and operating mines is $21.6, with 95% CI $9.0 to $36.2.

Figure 9: Expected private sector impact per $1 EIS investment (NPV)



Note: Bootstrapped distributions.

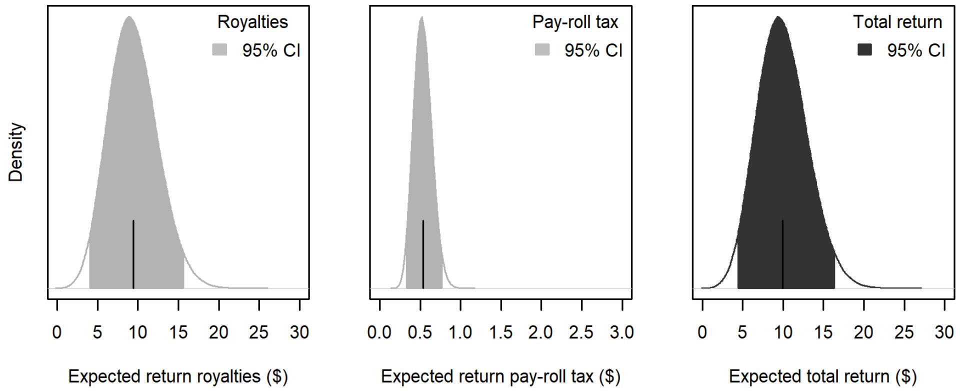
3.4.2 Government sector impacts

The return to the Government of Western Australia comes primarily through royalty income and pay-roll tax. Details on the expected return to government, per $1 invested in the EIS from pay-roll tax, royalty income, and combined, are shown in Figure 10.

The results provide clear evidence that: the return to the State government is positive. The mean combined pay-roll tax and royalty income expected return is $9.9 per dollar invested, with 95% CI $4.4 to $16.4.

From Figure 10 it is also clear that the main return to government channel is royalty income. The mean expected return from pay-roll tax is $0.53 per dollar invested, with 95% CI $0.33 to $0.77; and the mean expected return from Royalty income is $9.4 per dollar invested, with 95% CI $4.0 to $15.7.

Figure 10: Expected return to government per $1 EIS investment (NPV)



Note: Bootstrapped distributions.

4 Return to Western Australia

The stage one and stage two modelling in Chapters 2 and 3 described the total impact of investment in the EIS. The return to government was defined in terms of royalty income and payroll-tax income received; and the return to the private sector was defined in terms of the net private sector wealth created, and the benefit due to additional exploration and construction activity. Issue of horizontal fiscal equalisation across Australian jurisdictions are beyond the scope of this report.

Some of the total benefits flow to non-residents of Western Australia, and some of the additional exploration activity is a redirection of funds from other activities rather than net new investment into Western Australia.

Following the format of ACIL Allen (2015), the return to Western Australia is defined as the additional exploration expenditure attracted to Western Australia from outside Western Australia; the additional construction investment spending attracted from outside Western Australia during the mine construction stage; that proportion of additional net private sector wealth held by residents of Western Australia; and the royalty and payroll-tax received by the Government of Western Australia.

The remainder of this chapter presents:

i) Base case return to Western Australia estimates

ii) Sensitivity analysis that explores the role of the discount rate assumption and the type of exploration activity stimulated assumption, and

iii) A reconciliation of the current findings to the findings reported in ACIL Allen (2015).

4.1 Base case return to Western Australia

For consistency with previous analysis, the assumptions used to determine the return to Western Australia are that: 50% of the funds raised for exploration and construction are external to Western Australia, and that 50% of established mine wealth flows out of Western Australia. With these assumptions 50% of the funds raised for exploration and mine construction are treated as a net gain to Western Australia, and 50% of the expected net wealth creation leaves the State.

4.1.1 Financial impacts

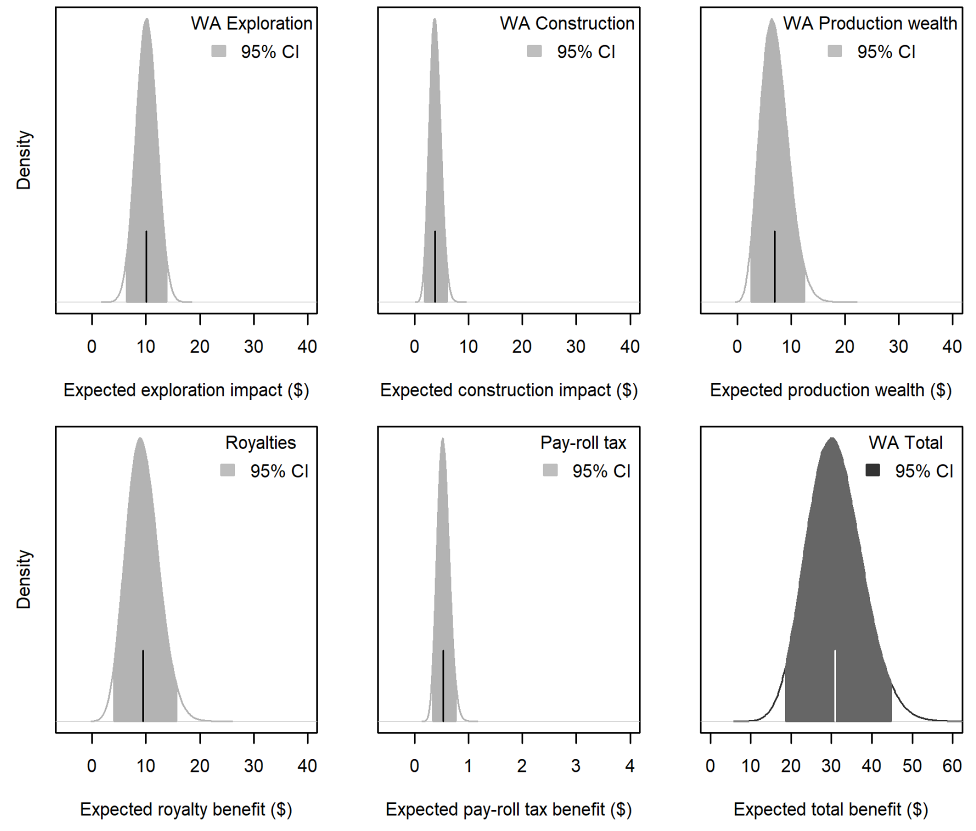
A summary of the various elements of the expected return to Western Australia is provided in Figure 11. The central estimate for the total return **is $30.8 per dollar invested, and the 95% CI range is $18.5 to $44.8.**

The components of the total return are:

- Exploration impact: $10.1, with 95% CI $6.3 to $13.8
- Construction impact: $3.8, with 95% CI $1.8 to $6.0
- Production wealth: $7.0, with 95% CI $2.5 to $12.5
- Royalty income: $9.4, with 95% CI $4.0 to $15.7, and
- Pay-roll tax: $0.5, with 95% CI $0.3 to $0.8.

The two largest components of the total return to Western Australia are the net additional funds attracted to Western Australia for exploration activity, and royalty payments to the Government of Western Australia as the community return from resource extraction.

Figure 11: Expected return to Western Australia per $1 EIS: base case (NPV)



Note: Bootstrapped distributions.

4.1.2 Employment impacts

Describing expected employment impacts is complicated, as it is necessary to consider both the length of activity and the scale of activity, jointly. To make the assessment tractable we follow the approach used in ACIL Allen (2015) and describe the impact when all variables are set at the central values. With these settings the expected employment impacts per $1M invested in the EIS are:

- 18.0 FTE, for 3.0 years, as the exploration impact
- 27.8 FTE for 1.8 years, as the mine construction phase impact, and
- 10.7 FTE for 15.1 years, as the operating mine phase impact.

4.2 Sensitivity scenario analysis

As part of the sensitivity analysis, both the role of the discount rate assumption and the role of mineral discovery type is explored. The sensitivity analysis that follows demonstrates that the main result of a strong positive state benefit is robust to alternative assumptions.

4.2.1 Impact of the discount rate assumption

Here we consider the impact of varying the discount rate assumption. In scenario one, the government discount rate assumption is increased from 4% to 7%, and the private sector discount rate assumption is increased from 10% to 12%. In scenario two, the government discount rate assumption is decreased from 4% to 2%, and the private sector discount rate assumption is decreased from 10% to 8%.

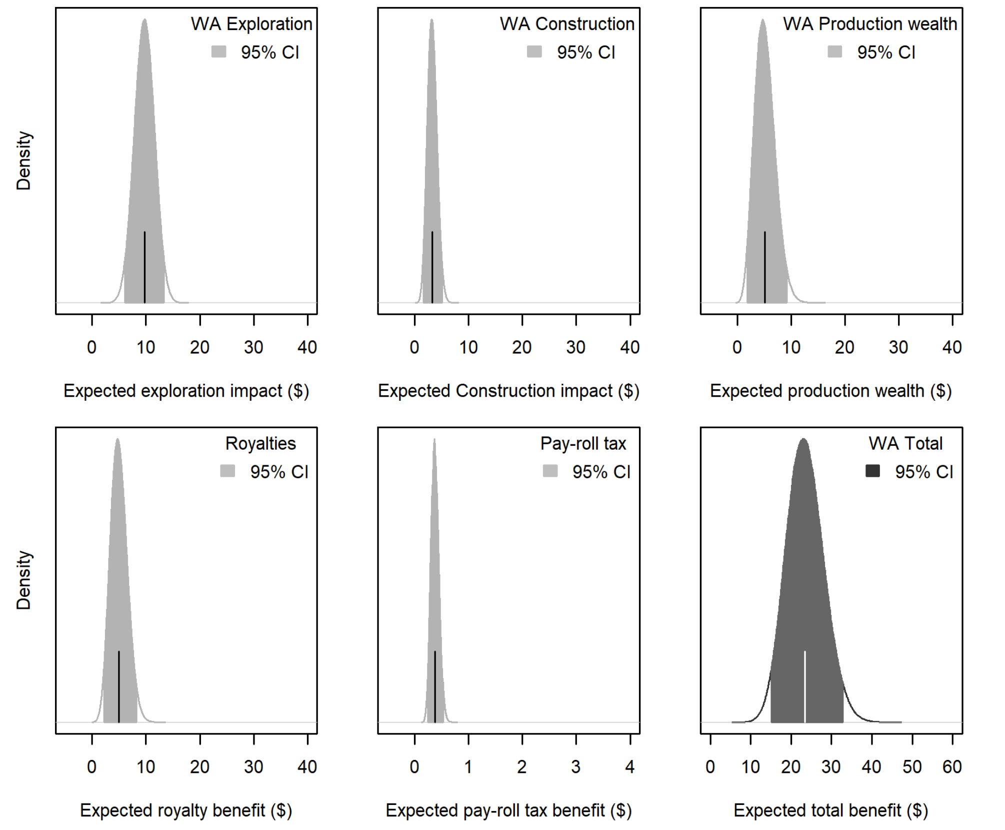
Higher discount rate scenario

Figure 12 provides a summary of the results, when higher discount rates are used, and returns are uniformly lower. With a higher discount rate assumption, the central total benefit to Western Australia estimate falls from $30.8 to $23.5, with 95% CI $15.0 to $32.8.

The respective estimates for each component of the total return are:

- Exploration impact: $9.7, with 95% CI $6.1 to $13.3
- Construction impact: $3.2, with 95% CI $1.6 to $5.1
- Production wealth: $5.1, with 95% CI $1.8 to $8.2
- Royalty income: $5.0, with 95% CI $2.1 to $8.2, and
- Pay-roll tax: $0.4, with 95% CI $0.2 to $0.5.

Figure 12: Expected return to Western Australia per $1 EIS: high discount rate



Note: Bootstrapped distributions.

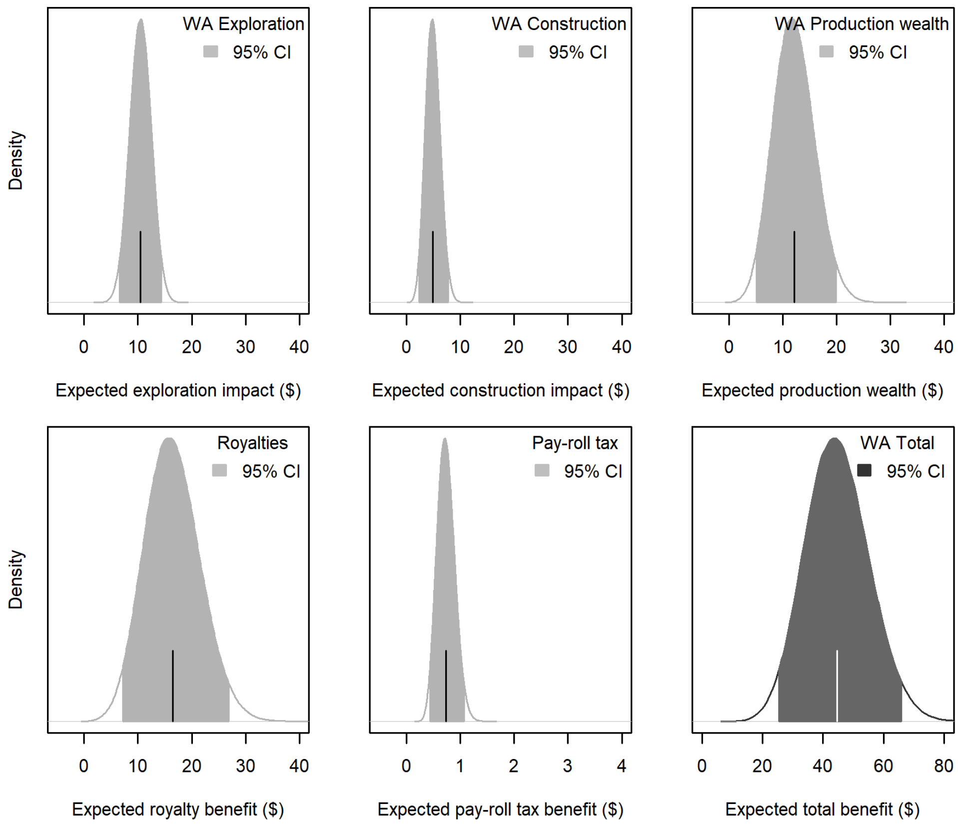
Lower discount rate scenario

Figure 13 provides a summary of the expected results, when lower discount rates are used, and returns are uniformly higher. With a lower discount rate assumption, the central total benefit to Western Australia estimate increases from $30.8 to $44.7, with 95% CI $25.4 to $65.9.

The respective estimates for each component of the total return are:

- Exploration impact: $10.5, with 95% CI $6.6 to $14.3
- Construction impact: $4.9, with 95% CI $2.3 to $7.7
- Production wealth: $12.1, with 95% CI $5.1 to $20.0
- Royalty income: $16.4, with 95% CI $7.1 to $26.9, and
- Pay-roll tax: $0.7, with 95% CI $0.4 to $1.1.

Figure 13: Expected return to Western Australia per $1 EIS: low discount rate



Note: Bootstrapped distributions.

4.2.2 Impact of mine type discoveries

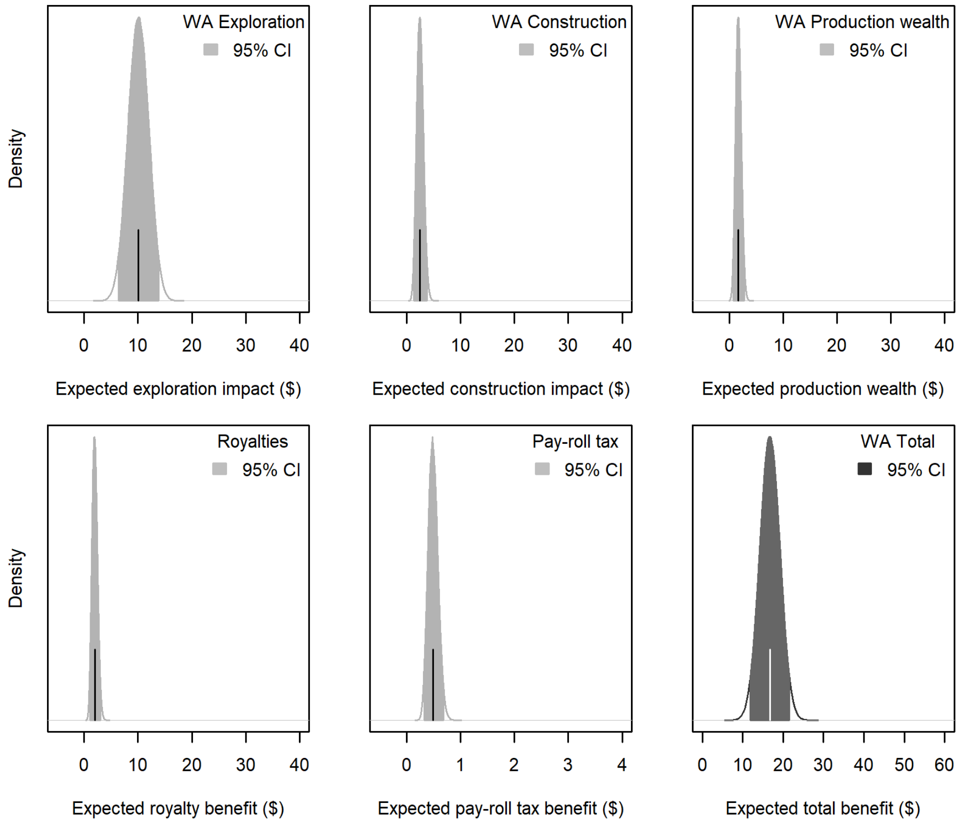
The base case model assumes that additional drilling can trigger gold, nickel, or iron ore discoveries. Iron ore mines in Western Australia can have a very long life; and have been a substantial driver of both private sector wealth, and royalty income (see Figure 15). Western Australia is the world's leading supplier of iron ore, with a global market share more than twice that of the second supplier, Brazil; the cash cost of production is low (see Figure 15); and Australia's major export ports are close to key markets. More specifically, iron ore production dominates the Western Australian economy, and in 2019 the iron ore industry accounted for 20% of Gross State Product; 82% of State Government royalty income; and 18% of State Government revenue (DJTSI 2020).

To explore the role of expected iron ore discoveries, the model was estimated under the assumption that the additional exploration activity stimulated by the EIS only stimulated activity associated with gold and nickel discoveries.

For this scenario the expected return to the State falls from $30.8 to $16.7 (95% CI $11.9 to $21.9).

The reduction in return is primarily through lower royalty income, which falls from $9.4 to $2.0 (95% CI $1.1 to $3.0); and lower expected new private sector wealth, which falls from $7.0 to 1.7 (95% CI $0.7 to $2.8).

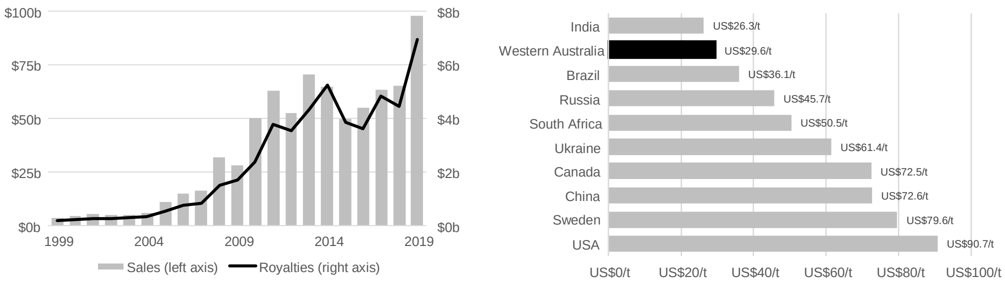
Figure 14: Expected return to Western Australia per $1 EIS: no iron ore



Given the high profitability of iron ore mines in Western Australia, the long mine life, and the baseline Royalty rate, it is not surprising that excluding iron ore results in a decrease in the expected benefit to Western Australia.

However, that there is still a strong positive expected return to EIS investment, once Western Australia's most important commodity is removed from the analysis demonstrates that the main result is robust, and not dependent on triggering additional iron ore discoveries.

Figure 15: Characteristics of iron ore industry in Western Australia



Source: Reproduced from DJTSI (2020)

4.2.3 Summary sensitivity analysis finding

The base case modelling results incorporate many sources of uncertainty, however some model parameters, such as the discount rate assumption and the type of exploration activity stimulated assumption reflect subjective choices. The sensitivity analysis established that the main study finding of a large positive net benefit from EIS spending is robust to alternative, plausible assumptions, for the discount rate and mine type discoveries.

4.3 Reconciliation to previous findings

4.3.1 Financial impacts reconciliation

A reconciliation of the previous finding to the current findings is presented in Table 7. So that the two sets of results are comparable, the earlier ACIL Allen (2015) estimates have been adjusted for inflation to 2020 equivalent values.

For the ACIL Allen (2015) estimates the central estimate value is reported and the values in parentheses represent the high to low range. For the current study the central estimate is reported, along with the 95% CI. The transfers between the government and the private sector have been netted out from the return to the private sector, and do not represent double counting.

Table 7: Benefit comparison per $1M invested in the EIS (2020 dollars)

Category	ACIL Allen (2015)	Current study
	$	$
Exploration expenditure	11.2 (0 -11.2)	10.1 (6.3 – 13.8)
Construction expenditure	4.2 (0 - 6.3)	3.8 (1.8 – 6.0)
Production wealth	3.6 (0 – 12.3)	7.0 (2.5 – 12.5)
Royalties	6.3 (0 – 11.2)	9.4 (4.0 – 15.7)
Pay-roll tax	0.4 (0 – 0.5)	0.5 (0.3 – 0.8)
Total	**25.7 (0 – 41.6)**	**30.8 (18.5 – 44.8)**

Note: For ACIL Allen values in parentheses represent high low range and for current study values in parentheses represent 95% CI.

Although the new central estimate is higher than the previous estimate ($30.8 compared to $25.7) the proportion of the area under the distribution estimate curve for the current study that lies within the high to low range of ACIL Allen (2015) study is 93%. This can be interpreted as representing broad agreement, in terms of findings, between the previous study and this evaluation, although the high low range for the previous study is relatively large.

The low case finding in the current study is always higher than the ACIL Allen report low case finding due to a difference in assumptions. The low case scenario in the ACIL Allen study considers a scenario where all commodity prices are uniformly low, for the entire future period, such that no matter what the level of EIS investment, there is no private sector exploration response. In the current study such a scenario falls outside the 95% confidence interval, hence the low case for the current study is always higher. The ACIL Allen report notes that the low case scenario represents an extreme outcome.

Royalty income is higher in the current study, in part due to the higher average gold price assumption. As detailed in Figure 8, the gold price has risen strongly since the previous report. As such, the model price assumptions for gold have been revised upwards for the current study.

The higher production wealth finding is in part due to the current study using a 10% real discount rate rather than a 12% real discount rate, as was used in the ACIL Allen study. When a matching 12% discount rate assumption is used the estimate for production wealth falls from $7.0 to $5.1, with 95% CI $1.8 to $8.2.

4.3.2 Employment impacts reconciliation

Similar to the financial impact reconciliation, the current study findings of impacts per $1M invested are in general more positive than the ACIL Allen 92015) findings. Expressed in terms of total FTE years, the ACIL Allen central estimate was 189 FTE years, and the current study estimate is 266 FTE years, per million dollars invested. The reason for the difference is largely due to a modest difference in the assumed average mine life for the central case between the two studies. A reconciliation of the sets of impacts is presented below:

- Exploration impact
  - 18.0 FTE, for 3.0 years (current) compared to 12.5 FTE, for 3 years (ACIL Allen)
- Mine construction impact
  - 27.8 FTE for 1.8 years (current) compared to 27.6 FTE for 2 years (ACIL Allen)
- Operating mine impact
  - 10.7 FTE for 15.1 years (current) compared to 7.4 FTE for 13 years (ACIL Allen).

Overall, the difference in the central case reflects different assumptions. The ACIL Allen (2015) study explicitly sought to use conservative assumptions, and so some potential upside scenarios are excluded from the ACIL Allen modelling. Here, the objective has been to consider a central best-case estimate, and then consider both upside and downside uncertainty. As this study includes potential upside scenarios not considered in the ACIL Allen (2015) report, it is natural that the central estimate in this study is higher than in the ACIL Allen (2015) study.

5 Supporting evidence

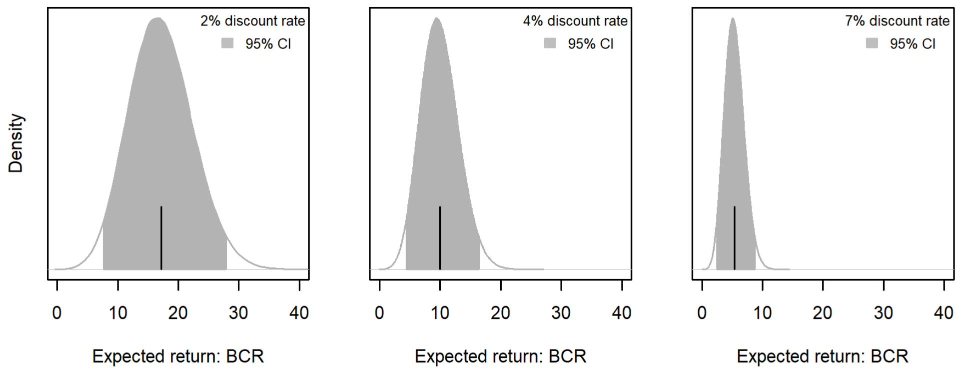
This chapter provides complementary supporting evidence that supports the main empirical modelling.

5.1 Peer-reviewed studies

The results showing a positive return to the Government of Western Australia from EIS spending are consistent with the limited number of peer-reviewed studies that have estimated the return to Government from investment in geoscience type activities. Peer-reviewed studies have tended to emphasise the benefit-cost ratio metric to assess impacts. For example, Scott et al., (2002) report benefit-cost ratios for government investment in geoscience of between 4.7 and 6.2 for Queensland, with a 6% discount rate; Fogarty and Sagerer (2016) report mean benefit-cost ratios of between 5.2 and 9.0 for Western Australia, with discount rates varying between 5% and 9%; and Gildemeister et al. (2018) report a central estimate of 11.5 as the benefit-cost ratio for public geoscience expenditure in Chile, where a 10% discount rate is used.

Figure 16 plots the benefit-cost ratio distribution from the government perspective from this analysis, at three different discount rates, and the central estimates are 17.0 with a 2% discount rate, 9.9 with a 4% discount rate, and 5.8 with a 7% discount rate. Overall, when the results are expressed in benefit-cost ratio terms, the results are broadly consistent with the values reported in the peer-reviewed literature.

Figure 16: Expected benefit-cost ratio for government investment in the EIS



Note: Bootstrapped distributions.

5.2 A pipeline of projects

The modelling results are based on an expected value framework. Such a framework allows uncertainty to be appropriately incorporated into the government policy evaluation framework. As the EIS has been operational for more than a decade it is also appropriate to ask what actual on ground evidence exists on EIS performance. If the EIS is working as expected, it should be possible to identify some on-the-ground evidence of EIS funding leading to prospective developments that have good prospects of transitioning to an operating mine.

Here, three case studies are presented from three funding rounds that illustrate the expected pattern of development is present: there are operating mines where the development of the exploration drilling program benefited from EIS funding; there are highly developed projects that have progressed to the feasibility stage, that have directly benefited from EIS funded activities; and there are emerging prospects that have been developed as targets due to EIS funded activities, where external funding for extensive additional drilling campaigns has been secured.

The first case study describes an outcome from an early round of co-funded drilling in the Fraser Range where there has been a complete transition from a small exploration company that received co-funding for exploration drilling, to an operating world class mine. As part of this transition there was a dramatic increase in private sector wealth, and around $500M was spent on mine site construction. As an operating mine the State government is now receiving royalty income from this mine. Co-funding was provided in Round 3 (2011-12), but the overall drilling campaign also relied on historical GSWA precompetitive data resources.

The second case study describes a small exploration company that received co-funding for drilling that is currently at the point of commissioning a feasibility study for a new, large, world class gold mine. The company has experienced a rapid increase in value, has undertaken extensive additional exploration activity to prove up the resource and has been able to raise substantial funds from capital markets to fund the required additional exploration drilling and associated project development costs. Co-funding was provided in Round 15 (2017-18), and the overall campaign concept relied on GSWA maintained resources (e.g. Western Australian mineral exploration reports (WAMEX), such that historical context of mining in the region was known.

The third case study provides an example of a small exploration company that has received co-funding for drilling and has been able to leverage the preliminary results into a farm-in arrangement with a large established mining company that is willing to fund substantial additional exploration drilling to investigate the resource base. This demonstrates a pathway from initial exploration to substantial new privately funded exploration activity in a potential emerging resource province. Co-funding for drilling was received in various funding rounds, and this example demonstrates why a large private sector multiplier, as found in the stage 1 modelling reported in Chapter 2, is realistic.

5.2.1 Nova nickel project

The Nova nickel mine in the Fraser Range represents a valuable case study that can place the abstract modelling results in context. As detailed in a range of ASX announcements and reports, initial exploration activity for the project made use of data from various sources, including historical data from the 1960s; GSWA geophysics and soil sample information; and drilling activity was directly supported by the EIS.[2]

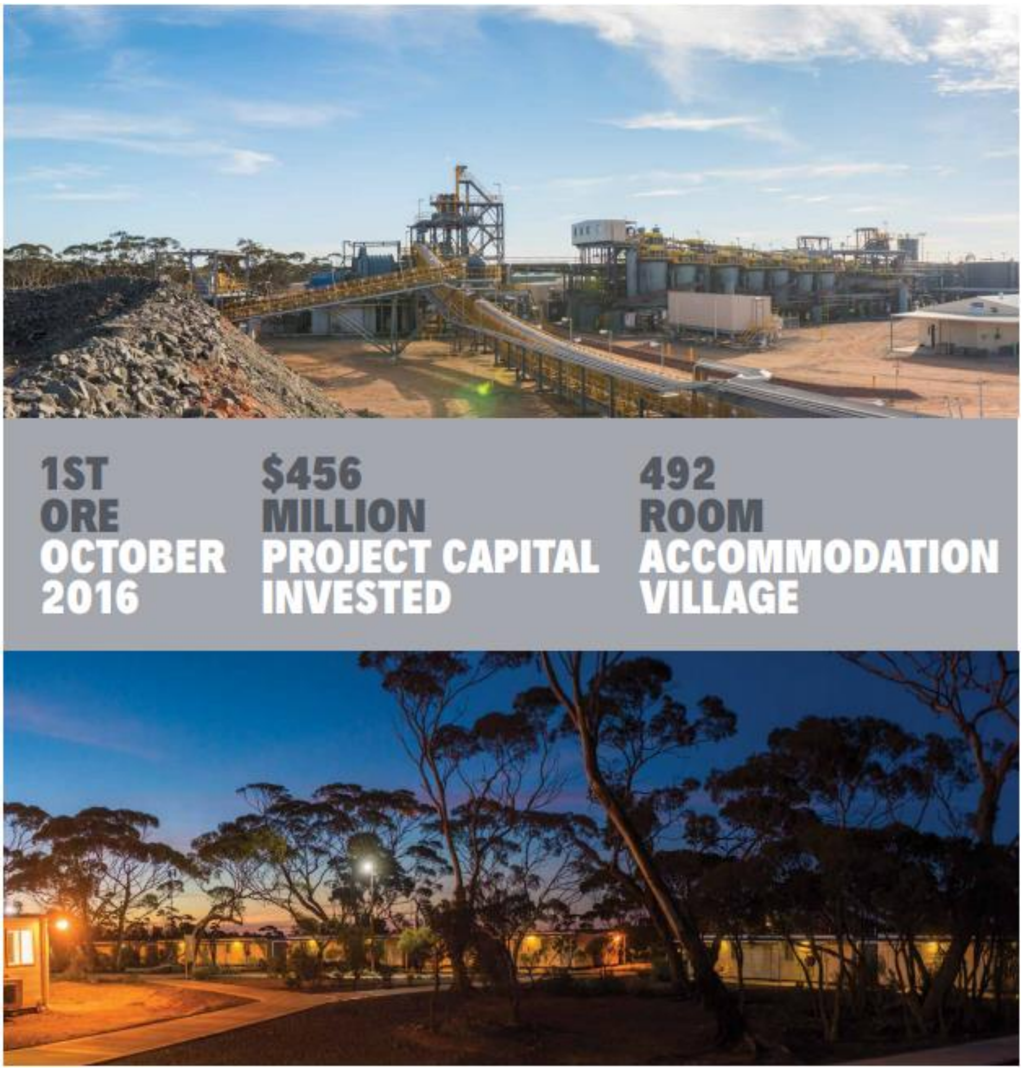
In December 2011 Sirius Resources had a market capitalisation of $13M and was undertaking drilling co-founded through the EIS in the Fraser Range, where the prospectivity of the region was generally regarded as low, but emerging exploration results on the back of earlier pre-competitive geoscience data suggested the potential for gold and nickel was high (Bennett 2011). This co-funded drilling program led to the development of the Nova Nickel mine, currently operated by IGO Limited (IGO).

[2] ASX announcement Sirius Resources Limited 20 January 2010 illustrates the role of historical GSWA geochemical sampling.

Following the initial discovery in 2012, substantial additional work was undertaken to prove up the Nova resource base, and by the end of 2014 a definitive feasibility study had been completed. At the time the definitive feasibility study had been completed the value of Sirius Resources had risen to $1.2B. In 2015 the company was acquired by IGO for $1.8B. Over a four-year period there was an increase in wealth for equity owners in this junior exploration company of 140 fold.

The 2015 IGO Annual Report noted the expected cost of mine development for Nova as $443M; that the mine life will be ten years, and construction will largely be completed during the 2016 financial year. The actual construction cost was slightly higher than expected ($456M), but what is most notable is the relatively short time period from discovery to production. For example, the project proceeded to production approximately one-third faster than assumed transition timeline used in the Chapter 3 analysis.

Figure 17: Nova: production, construction, employment



Source: IOG 2017 Annual Report

The return to Government flows primarily from royalty payments, when the mine is operating. The first set of financial results available for the Nova mine are for the 2018 financial year, and the accounts show that mine total revenue was $349M, from 1.5M tonnes of mined ore. Subsequent Annual Reports indicate that in 2019 revenue was $502M, from 1.5M tonnes of mined ore; and in 2020 revenue was $593M, from 1.5M tonnes of mined ore. The associated royalty payments for these three years are around: $8.7M, $12.5M, $14.8M. The mine has a projected life of a further six years, but exploration results in related tenements are reported in the Annual Report as positive, and it is common for further exploration activity to result in an extension to an initial mine.

Assuming mine life is extended by two years due to prospective adjacent exploration, which is conservative, and that production levels and prices are similar to those over the past two years, the NPV of the royalty stream to the Government of Western Australia, referenced to the year of the initial drilling, is around $123M, $96M, and $68M, for discount rates of 2%, 4% and 7%.

The Nova operation employs around 460 people, and so provides substantial regional employment (IGO 2018).

This example illustrates that government investment through GSWA and the EIS is central to real world resource discoveries in Western Australia, and that these discoveries subsequently transition into operating mines, after substantial additional exploration to prove up the resource. Private sector wealth creation is substantial; construction investment is substantial; and operations provide a substantial financial return to the Government of Western Australia.

5.2.2 Bellevue gold prospect

At 30 June 2017, Bellevue Gold Limited (Bellevue) then trading as Draig Resources had a market capitalisation of $5.4M and was undertaking a drilling program 400km north-west of Kalgoorlie. It is notable that as a historical mining region, the world class geoscience data maintained by GSWA make it possible for areas to be re-investigated, in-light of new technology. Understanding what has happened in the past is important information for those seeking to undertake a new exploration campaign, and the data maintained by GSWA make this knowledge available.

Box 1: Example of reporting by companies on EIS co-funding

Exploration Incentive Scheme (EIS) co-funded drilling returns significant mineralisation from new target located to the East of Deacon

• The first two holes of a three-hole Western Australian Government co-funded EIS program drilled into the area to the east of the Deacon Shear intersected gold, revealing the potential for another lode. Gold mineralisation is associated with quartz-pyrrhotite veining and free gold, analogous to the Bellevue, Deacon and Viago lodes.

• The results included:

• 1.2m @ 9.0g/t gold from 1,057m and 1.6m at 9.3g/t gold from 1,096m downhole in DRDD327 extension

• a 400m step out drill hole to north with 0.4m @ 42.3g/t gold from 646.7m downhole in DRDD309 extension

Source: ASX ANNOUNCEMENT 29/10/2020: Bellevue September 2020 Quarterly Report

Following an initial discovery drill hole in November 2017, a maiden resource of 0.5M oz at a grade of 8.2 g/t was declared in October 2018. A subsequent extensive drilling program has increased that resource base to 2.4M oz at 10.0 g/t as of November 2020; with an associated increase in market capitalisation to $1.1B (Bellevue 2020).

The company has undertaken an extensive drilling program to prove up the resource. In the last quarter of 2020, the company was operating six drill rigs at the site; had drilled 300,000 meters of diamond drill core; and had an ongoing exploration budget for near mine and greenfield targets of $35M; and $150M cash on-hand to fund development activities (Parsons 2020).

The 2020 Annual report (p. 5) notes the following features of the project: (i) one of the highest-grade discoveries in a leading jurisdiction for mining (10g/t); (ii) very low discovery cost per oz ($18/oz); (iii) the strong cash position of the company ($151M); (iv) the scale of the project (2.3M oz); and (v) high recovery rate from test work completed (97.3%). Additionally, the project is close to established infrastructure for power and water, accessible from Leinster, which is serviced with a daily flight to Perth; and the gold price is high. Combined these features suggest a high probability that the project will progress to an operating mine in a relatively short period of time.

Figure 18: Underground portal works at Bellevue (September 2020)

Source: Bellevue (2020)

This case study illustrates that following a drilling campaign supported by co-funding, and access to GSWA databases for historical activity, large subsequent exploration campaigns can be triggered; it is possible to raise substantial funds from capital markets; and that it is highly likely in the future there will be additional royalty income flowing to the Government of Western Australia from a new globally significant gold mine.

Table 8: Bellevue resource development timeline

Date	Key resource detail
November 2017	Discovery drill hole: 7m at 27.4 g/t
September 2018	Maiden resource: 0.5M oz at 8.2 g/t
October 2018	Resource Update: 1.04M oz at 12.3 g/t
February 2019	Resource Update: 1.53M oz at 11.8 g/t
July 2019	Resource Update: 1.8M oz at 11.1g/t
February 2020	Resource Update: 2.2M oz at 11.3 g/t
July 2020	Resource Update: 2.3M oz at 10.0g/t
November 2020	Resource Update: 2.4M oz at 10.0g/t

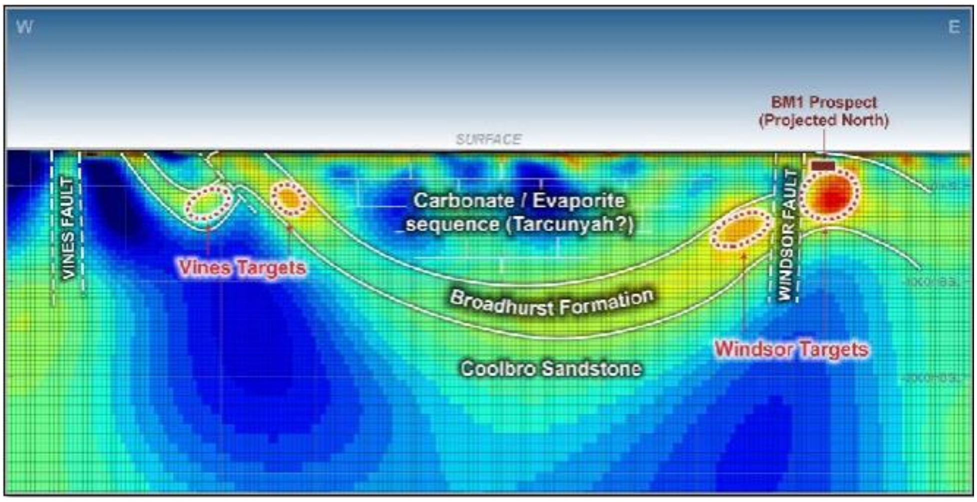
Source: Bellevue (2020)

5.2.3 Encounter Yeneena copper-cobalt project

Encounter Resources Ltd (Encounter) has undertaken a range of exploration projects in the Paterson province that have been supported through EIS funding. Funding has included several co-funded drilling campaigns across different blind targets, and use of regional precompetitive geophysical datasets. These activities have identified several large-scale copper-cobalt prospects.

To further develop the project, in 2020 Encounter entered into a farm-in agreement with IGO, for IGO to fund up to $15M of exploration activity over the next seven years. For this exploration expenditure funding, IGO has the opportunity to earn a 70% interest in the project.

Figure 19: Interpreted geology for copper-cobalt targets in Paterson-province that have been part of EIS co-funded drilling



Source: Encounter (2020)

This project is still at the very early stage, but this case study example demonstrates that initial exploration activity can leverage substantial new private sector funds for additional exploration. This example directly supports the high exploration multiplier estimate, as it demonstrates a path from initial drilling to a substantial subsequent private sector drilling program that would not otherwise have taken place.

The example also demonstrates that EIS funding is supporting the creation of a continuing pipeline of potential projects, that may transition to operating mines.

Figure 20: Encounter annual report highlighting EIS funding

> In June 2020, the Company was successful in its application for a WA Government Exploration Incentive Scheme ("EIS") co-funded drilling grant of up to $150,000 to test the Windsor and Vines targets at Yeneena.
>
> The EIS co-funded diamond drill program is scheduled to commence in November 2020.

Source: Encounter (2020)

6 Conclusion

The EIS is a targeted government program that addresses the widely acknowledged market failure issues that result in private sector underinvestment in greenfield exploration.

Through the provision of pre-competitive geoscience information, platforms for data use, and direct support for exploration drilling, the EIS is able to address this market failure issue and stimulate substantial additional exploration activity.

Due to the highly favourable mineralogy in Western Australia, and world class legislative framework and infrastructure, addressing this market failure issue delivers substantial net benefits to Western Australia.

Using conservative assumptions, ACIL Allen (2015) found that, in 2020 dollars, the long run expected benefit to the State per dollar invested in the EIS was $25.7 (range $0 - $42). This benefit comprised new funds attracted to Western Australia, new private sector wealth creation, and a return to government via taxes and royalty payments.

Using a similar methodology, this study has found that the long run expected benefit to Western Australia per dollar invested in the EIS is $30.8 (95% CI $18.5 to $44.8). These benefits, decomposed into their component parts, comprise:

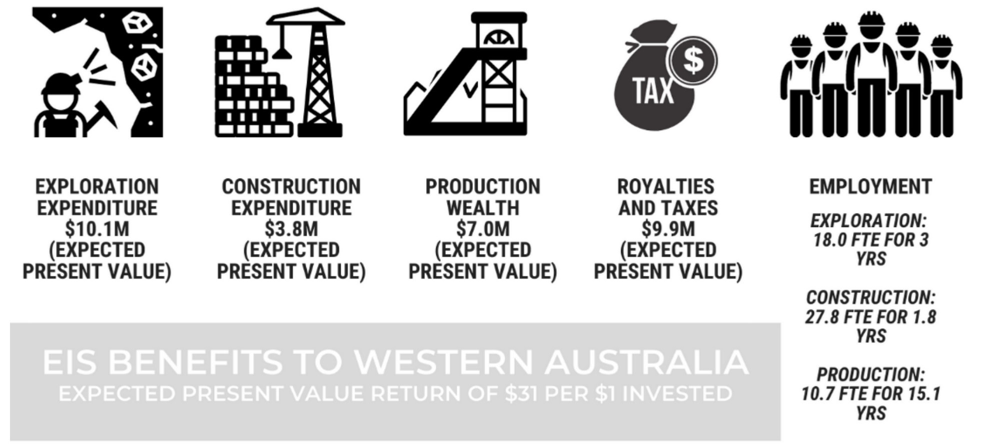
- exploration impact: $10.1M (95% CI $6.3M to $13.8M)
- construction activity impact: $3.8M (95% CI $1.8M to $6.0M)
- production wealth impact: $7.0M (95% CI $2.5M to $12.5M)
- royalties and taxes $9.9M: (95% CI $4.4M to $16.4M)

The associated employment impacts per $1M invested were found to be:

- 18.0 FTE, for 3.0 years, as the exploration impact
- 27.8 FTE for 1.8 years, as the mine construction phase impact, and
- 10.7 FTE for 15.1 years, as the operating mine phase impact.

The high benefit to Western Australia estimate was found to be robust to different discount rate and mineral success scenarios, and is a robust result. A summary of the expected impacts, per $1M invested in the program, is shown at Figure 21.

Figure 21: Benefit per $1M invested in the Exploration Incentive Scheme



Appendix A

A.1 Overview of dynamics

The way dynamics are introduced into the model can be understood as follows. Let there be a change in market conditions, for example, let the relevant commodity price increase. In response to the increase in the commodity price level, firms may want to increase exploration activity, as the return to a successful drilling campaign has increased. Despite the immediate desire of the firm to increase exploration activity, it takes time to raise funds, organise the drilling program, etc.; and as such, the extent of the contemporaneous response is mediated by the real world business frictions involved in operationalising the desire to increase exploration activity.

Further, it is assumed that the larger the change in market conditions, the greater the desired change in activity. If commodity prices change a lot, it is reasonable to expect a large change in exploration activity, in the long run; and if the change in commodity prices is modest, it is reasonable to expect only a modest change in exploration activity.

A.2 A formal model of market dynamics

Formally, the above description of the dynamics for the way exploration activity responds to changes in market conditions can be incorporated into a model as follows. Let Q_t^* denote the target level of greenfield exploration expenditure at time t (which is not observed); given government EIS expenditure E_t; other government expenditure on general geoscience and related service, denoted G_t; and market conditions, as measured by M_t, which is found as the first principle component from analysis of the iron ore, gold, and nickel price. The model can then be written as:

$$Q_t^* = \alpha + \beta_1 E_t + \beta_2 G_t + \beta_3 M_t \tag{3}$$

The main issue with this expression is that the key variable, which is target exploration expenditure Q_t^* is not observed. What is actually observed is Q_t, the actual level of exploration activity at time t.

Dynamics can be incorporated by assuming that the extent of the change in exploration activity between any two periods depends on the difference between actual expenditure on exploration in the previous period, and the target level of expenditure in the current period. Formally, this relationship can be written as:

$$Q_t - Q_{t-1} = \gamma[Q_t^* - Q_{t-1}], \tag{4}$$

where γ is the speed of adjustment parameter. The above expression says that the observed change in exploration activity is proportional to the difference between the level of exploration in the previous period and the target level of exploration activity in the current period, which reflects current market conditions. Based on the logic described for the context of partial adjustment to business frictions $0 < \gamma < 1$. Note, rearranging equation (4) gives:

$$Q_t \;= Q_t^*\gamma + Q_{t-1}[1-\gamma], \tag{5}$$

which says that the level of exploration activity observed in the current time period is the weighted average of the level of exploration activity in the previous period, and the target level of exploration for the current period.

To obtain a model completely in terms of observable information, note that equation (5) can also be written as:

$$Q_t^* = \frac{Q_t}{\gamma} - \frac{Q_{t-1}}{\gamma} - Q_{t-1}. \tag{6}$$

The right hand side of equation (6) can then be used to replace the left hand side of equation (3) to give:

$$\frac{Q_t}{\gamma} - \frac{Q_{t-1}}{\gamma} - Q_{t-1} = \alpha + \beta_1 E_t + \beta_2 G_t + \beta_3 M_t, \tag{7}$$

Following simplification, the expression collapses to:

$$Q_t \;= \gamma\alpha + \gamma\beta_1 E_t + \gamma\beta_2 G_t + \gamma\beta_3 M_t \;+ (1-\gamma)Q_{t-1}. \tag{8}$$

The expression defined by equation (8) is a model written completely in terms of observable values, and hence can be estimated. The short run impact of government EIS expenditure on private sector exploration activity is described by the term $\gamma\beta_1$, which is estimated directly by the model. Long run impacts are defined by the move from one equilibrium position to another. Using Q', E', G', and M' to denote long-run equilibrium values this substitution gives:

$$Q' = \gamma\alpha + \gamma\beta_1 E' + \gamma\beta_2 G' + \gamma\beta_3 M' \;+ (1-\gamma)Q', \tag{9}$$

which can then be rearranged to give:

$$Q' = \alpha + \beta_1 E' + \beta_2 G' + \beta_3 M'. \tag{10}$$

Equation (10) says that the long-run impact of government EIS expenditure on private sector exploration activity is given by the β_1 term. In the equation estimated in terms of observables, the parameter estimate associated with current period EIS expenditure is $\gamma\beta_1$, and the parameter associated with lagged exploration activity is $(1-\gamma)$. The long-run impact is therefore found as the ratio of the parameter estimate associated with contemporaneous EIS expenditure, divided by one minus the parameter estimate associated with one period lagged private exploration expenditure.

The variance of the ratio of two normally distributed random variables is not defined, but the it is possible to approximate variance via the delta method. As such, it is also possible to describe both the best guess estimate of the long run impact and the extent of uncertainty surrounding that estimate, as described by the estimate standard error.

Note that although the model has been explained in terms of a backward looking business outlook, in the sense that the adjustment process is defined by the difference between past actual expenditure, and target current expenditure, the rational expectations model, where exploration investment decisions are forward looking, is statically equivalent to a partial adjustment model. The practical implication of this is that even if firms form expectations of future market conditions, and then develop exploration investment decisions based on their expectations of the future, the formal statistical model used to represent such behaviour is the same as the model described above.

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JJ Fogarty