# The Impact of R&D Investment on the Financial Performance of Australian Junior Mining Firms: A Mixed Method Study

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**Abstract**

*Junior mining firms (JMF) are characterized by unique fundamentals and significant uncertainty. This context challenges the accurate valuation of R&D ventures by JMFs. This study examines the effect of R&D investment on both the market-based valuation and accounting performance of JMFs. Panel data from 2000 to 2022 through the lens of the knowledge-based view and real options theory reveals a robust positive association between R&D investment and JMFs' long-term market value, but a non-continuous negative relationship between R&D investment and accounting performance, suggesting that traditional accounting measures may not fully capture the value of R&D investments in this sector. Further, by employing a quasi-experimental difference-in-differences design to assess the impact of the Australian R&D Tax Incentive Policy, we find that the policy has beneficial effects on JMF performance through mitigating JMFs' financial constraints on R&D investment. Complementing our quantitative analysis, a mixed-method approach illustrates the key barriers and motivations for R&D engagement among JMFs. This study contributes to the understanding of R&D value in the junior mining sector specifically, offering practical insights for firms, investors, and policymakers on the significance of R&D investment and the role of government support.*

## 1. Introduction

It is well-known that innovation drives economic growth through productivity gains (e.g., Minniti & Venturini, 2017). However, firms tend to underinvest in innovation due to the inherent riskiness of research and development (R&D) projects, along with the fact that firms face financial constraints and difficulties in appropriating returns from their R&D investments (Hall, 2020). This issue is particularly pronounced among junior mining firms (JMFs),[1] small entities focused on mineral prospecting and holding mining tenures, without engaging in mining operations (Haslam and Tanimoune, 2016). Given their brief operational lifespans, targeted business objectives,[2] and limited resources, small firms, such as JMFs, are generally

[1] In accordance with CSIRO Australia's (2016) criteria, we employ a market capitalization threshold to distinguish JMFs from larger mining companies, defining JMFs as those with market capitalization below AUD$500 million.
[2] As outlined in Section 2.1, the primary focus for most JMFs is generating sufficient capital inflows to sustain operations.

not anticipated to dedicate substantial resources to R&D projects (Audretsch et al., 2014).[3] Nonetheless, the increasing demands for innovation and sustainable development within the mining industry (Deloitte, 2019), alongside the inherent risks and the often delayed benefits associated with R&D projects (Curtis et al., 2020),[4] pose challenges for JMFs in making R&D investment decisions. This situation underscores the value in understanding whether and how R&D investment affects JMFs' market-based valuation and their accounting performance.

From a theoretical perspective, ex ante, it is unclear whether R&D investments can increase JMF market valuation. On one hand, R&D investment is likely to increase the market valuation of a JMF through increases in investor expectations of future cash flows arising from improved firm efficiencies and productivity (Hall et al., 2010) and expanded market share and sales growth (e.g., Aghion & Howitt, 1992). However, the inherent riskiness of R&D and specific risks associated with JMFs offset these potential gains (Haslam & Tanimoune, 2016). For example, at the industry level, mining firms face specific risks such as financing, native-title issues, fluctuations in commodity prices and currency, challenges related to power and water supply, and technical, logistical, operational, and environmental concerns, including regulations (Rudenno, 2004). Additionally, JMFs face unique challenges, including limited access to cooperation and knowledge, lack of R&D experience, and financial constraints (Haslam & Tanimoune, 2016), which can impede R&D development and value generation. Furthermore, the information asymmetry associated with innovative activities complicates investors' ability to accurately assess their value (Heeley et al., 2007). Unlike the ambiguous implications of market valuation, which might suggest positive outcomes, accounting performance may fail to capture the intrinsic value of R&D investment undertaken by JMFs. The profitability derived from R&D is contingent upon investment opportunities and the expected and required returns, which are influenced by the nature and costs of the R&D as well as the characteristics of the firms engaging in it (Curtis et al., 2020). Many JMFs are in a pre-production phase, marked by absent earnings and negative cash flows (Iddon et al., 2015), a situation that makes accounting data inadequate for capturing the actual worth of R&D investments (Hogan et al., 2002). Thus, we posit that R&D investment imposes a minor or even negative effect on JMF accounting performance due to the financial statement impacts of increased expenditure and lack of current earnings.[5]

# 2. Research Method

This study traces the R&D intensity and firm performance of a panel of junior mining firms listed on the Australian Securities Exchange (ASX) from 2000 to 2022. Annual accounting and financial data are collected from COMPUSTAT Global. The firms operating in the mining industry are identified using the Global Industry Classification Standard (GICS) code, which for mining is 151,040. To focus on junior mining firms in Australia, the sample is limited to firms that are legally incorporated in Australia (FIC), and whose market capitalization is less than AUD$500 million (CSRIO Australia, 2016). To control for the bias in R&D disclosure

[3] This study explicitly excludes drilling programs solely aimed at expansion and identification of new areas from its definition of R&D projects. Instead, we define R&D investment as initiatives that surpass mere mineral discovery, highlighting efforts that contribute to technological advancement and sustainable development.

[4] R&D projects carry inherent risks due to the uncertain outcomes of exploring new technologies or processes (Hsu et al. 2013); financial returns are often delayed as benefits like improved efficiency or new product development emerge over time, and a certain number of years is needed for the correction of market mispricing (Eberhart et al. 2004).

[5] We note that IFRS 6 / AASB 6 *Exploration for and Evaluation of Mineral Resources* provides companies with the option to capitalise exploration and evaluation costs under specified circumstances.

and to preserve the sample size, following previous studies (e.g., Koh et al., 2018), we retain observations with missing R&D expenditure data, and replace the missing R&D expenditure with zero. The above sample selection process yields a data set of 8,890 firm-year observations for Australian junior mining firms during the period 2000 – 2022, although actual sample sizes in our analyses vary due to availability of future periods. For instance, when we cumulate five years of future Tobin's Q in the dependent variable, the sample size drops because of insufficient future years (e.g., only one year of future data exists for reporting periods ending in 2022) as well as sample attrition (e.g., junior firms delistings).[6]

To evaluate the effect of R&D investment on JMFs' market valuation and accounting performance, we run panel data regressions of *Tobin's Q* and *ROA* on R&D intensity separately.

$$Tobin\ q_{it+3,it+4,it+5}/ROA^{Adj}{}_{it+3,it+4,it+5} = \beta_0 + \beta_1 R\&D\ Intensity_{it} + \beta_m \sum Control\ Variables + \sum \beta_k\ YEAR\ FE + \sum \beta_n\ SubIndustry\ FE + \varepsilon_{it}$$

where *i* indexes firm, and *t* indexes year. We measure a firm's R&D investments as its R&D intensity (Ehie & Olibe, 2010), calculated as the two-year average of the ratio of R&D expenditure to sales (Curtis et al., 2020). Following prior studies (e.g., Fauver et al., 2017), we use Tobin's Q as the market-based indicator of firm value. As Tobin's Q reflects the market's evaluation of a firm's prospects when taking all the available information into account (Miller et al., 2015), it is a forward-looking, market-based measure of a firm's valuation. We use return on assets as the measure of firms' accounting performance. We adjust income by adding back R&D, advertising, and depreciation expense to get adjusted ROA (hereafter $ROA^{Adj}$) (Curtis et al.2020). Thus, future values of net income are not mechanically reduced by future R&D expenditure. Prior studies have identified a time lag effect of R&D investment, due to the time required to transform R&D inputs into practical applications (e.g., Curtis et al., 2020). To be able to examine the lagged effect of R&D investment on JMFs' performance in a regression model, a plausible time period had to be defined a priori in which these lagged effects could appear. Findings drawn from the literature and results of studies on similar subjects could be used to assume a lag of up to 5 years (Schilling, 2015). We thus use different year-lag structures between our dependent and independent variables to capture the time-lag effect on R&D activities. Finally, we include year fixed effects and sub-industry fixed effects to control for the within-year and within-sub-industry change in the outcome variable. All continuous variables are winsorized at the 1st and 99th percentiles to mitigate the impact of outliers.

# 3. Results and Discussion

The regression analysis presented in Table 1 examines the long-term effects of R&D investment on market-based firm valuation and accounting-based profitability by employing various lag

[6] Our descriptive statistics (untabulated due to the limited space) show that the mean firm value stands at 4.054, with the average adjusted net income being -1.936 million AUD. Consistent with earlier discussions, JMFs typically face significant initial expenses for exploration, evaluation, and development of mining projects. These activities are capital-intensive and often extend over several years. Until a mine becomes operational and begins producing and selling minerals, JMFs usually have limited or no revenue. However, they continue to incur costs for exploration, administration, and project development. These expenditures are often expensed immediately according to accounting standards, further contributing to negative net income. This observation aligns with findings from previous mining studies in other countries (e.g., Rafiq et al., 2016). The positive Tobin's Q and the negative adjusted ROA implies that accounting-based profitability is not the key consideration in the valuation of JMFs. From the summary statistics it can also be observed that the average R&D intensity among the sample is 1.1%, with a notable number of Junior Mining Firms (JMFs) not engaging in R&D investment.

structures. Specifically, the study considers Tobin's Q and adjusted ROA as dependent variables across three different year-lags (t + 3, t + 4, t + 5) to measure the impact of R&D intensity. In columns (1)-(3), results using Tobin's Q reveal a statistically and economically significant increase in the Tobin's Q associated with R&D intensity across all year-lag structures, suggesting that JMFs with higher R&D intensity tend to have better market perceptions than JMFs with lower R&D intensity.[7] Specifically, R&D intensity has an association of 5.175 ($p$ = 0.006) in the third year, 5.173 ($p$ = 0.008) in the fourth year, and 5.160 ($p$ = 0.014) in the fifth year. We see the impact diminishes with longer time lags for JMFs, indicating a decreasing association between R&D investments and future market benefits as time progresses, which aligns with previous research (Curtis et al. 2020). These findings support that R&D intensity has a positive effect on market value in the long run. In contrast, columns (4) to (6) reveal a different dynamic when we use adjusted ROA to capture firm performance. Here, a notable negative association between R&D intensity and adjusted ROA is evident in the first two lag periods (t + 3 and t + 4). By the (t + 5) lag, this negative association is no longer significant. In light of the industry-specific backdrop, the regression results underscore the fact that for JMFs, the conventional net-earnings-based accounting measures, such as ROA, may not fully capture the value of R&D investments. This observation is consistent with the industry's trajectory, where significant initial investments precede operational maturity and revenue generation. The findings in columns (4) – (6) are consistent with our prediction that R&D intensity has a negative effect on JMFs' accounting-based performance even in the long run.

Overall, the results in Table 1 indicate that R&D intensity exhibits a non-continuous negative impact on JMFs' operating performance (as measured by ROA) yet yields a robust positive effect on their firm value (as indicated by Tobin's Q). The discontinuous relationship between R&D intensity and ROA underscores that the historical cost of balance sheet assets and liabilities may not reflect the true value of JMFs' R&D investment. As a result, using revenue-based accounting measures is difficult to translate into a strategy for valuing specific JMFs. On the other hand, the positive value effects of R&D reveal that investors appear to value the long-term benefits of JMFs' R&D activities. In other words, R&D investment is a positive value-creating strategy for JMFs from investors' perspective.[8]

Moreover, in our untabulated analysis, we supplement our analysis by using a difference-in-differences (DID) design and employing the Australian R&D tax incentive regime of 2012 as an exogenous shock affecting JMFs' R&D investment behavior, we are able to draw inferences regarding the economic consequences and efficacy of governmental policy support for R&D engagement among JMFs in Australia. To unpack the underlying motivations and barriers of R&D investment by JMFs, this study further utilizes a qualitative research approach in the form of semi-structured interviews with JMF management, thereby offering deeper insights.

[7] Our untabulated results for the current year and two years forward are insignificant regarding R&D's market valuation effect, suggesting that the market perceives R&D investments as risky for the short term. This perception leads to lower valuations due to skepticism about the immediate returns on R&D spending.

[8] We conduct a series of robustness tests. We employ the entropy balance method to control for observed differences between firms engaged in R&D projects and those without such investment experience. We also use Two-Stage Least Squares to mitigate potential endogeneity issues, such as reverse causality and omitted variables, which might bias the estimation of R&D impact. Additionally, we exclude observations with missing R&D expenditure values in each regression. We further exclude firm-year observations during the financial crisis (i.e., 2008) and the COVID-19 years (i.e., 2020 and 2021) to isolate effects unrelated to R&D investment impacts on JMFs' market valuation and accounting performance. We also utilize the natural logarithm of R&D expenditure as an alternative metric. Our inferences remain unchanged in all robustness tests (untabulated).

| Dep. Var. | (1) $Tobin\ q_{t+3}$ *Coeff.* *(t-stat)* | (2) $Tobin\ q_{t+4}$ *Coeff.* *(t-stat)* | (3) $Tobin\ q_{t+5}$ *Coeff.* *(t-stat)* | (4) $ROA^{Adj}_{t+3}$ *Coeff.* *(t-stat)* | (5) $ROA^{Adj}_{t+4}$ *Coeff.* *(t-stat)* | (6) $ROA^{Adj}_{t+5}$ *Coeff.* *(t-stat)* |
|---|---|---|---|---|---|---|
| ***R&D Intensity*** | **5.175*** ** | **5.173*** ** | **5.160** ** | **-0.661*** ** | **-0.500** ** | **-0.236** |
| | **(2.755)** | **(2.659)** | **(2.462)** | **(-2.677)** | **(-2.405)** | **(-1.190)** |
| *Capex* | 1.643 | 1.601 | 0.331 | 0.092 | 0.090 | 0.326*** |
| | (1.625) | (1.327) | (0.303) | (0.871) | (0.743) | (3.036) |
| *Cash* | 1.515** | 1.491** | 1.746** | -0.092 | -0.073 | -0.120 |
| | (2.558) | (2.296) | (2.561) | (-1.466) | (-1.054) | (-1.548) |
| *Size* | -1.476*** | -1.263*** | -1.085*** | 0.174*** | 0.161*** | 0.149*** |
| | (-12.270) | (-10.448) | (-8.548) | (13.283) | (11.401) | (9.879) |
| *LEV* | 11.513*** | 10.018*** | 8.915*** | -0.696** | -0.726*** | -0.756** |
| | (3.840) | (3.304) | (3.093) | (-2.527) | (-2.670) | (-2.507) |
| *INTANG* | 0.691 | -0.056 | -0.145 | -0.007 | 0.097 | 0.038 |
| | (0.630) | (-0.057) | (-0.135) | (-0.045) | (0.619) | (0.204) |
| Constant | 28.974*** | 23.664*** | 22.886*** | -3.342*** | -2.954*** | -2.861*** |
| | (10.040) | (7.908) | (7.163) | (-10.496) | (-8.799) | (-8.014) |
| Observations | 6,336 | 5,696 | 5,112 | 6,336 | 5,696 | 5,112 |
| R-squared | 0.093 | 0.078 | 0.061 | 0.073 | 0.060 | 0.053 |
| Year fixed effect | YES | YES | YES | YES | YES | YES |
| Sub-industry fixed effect | YES | YES | YES | YES | YES | YES |

**Table 1.** The Effect of R&D Investment on JMFs' Financial Performance This table presents the regression results of the long-term effects of R&D investment on market-based firm valuation and accounting-based profitability by employing various lag structures. In columns (1)-(3), the dependent variable, *Tobin q*, is calculated as total assets minus book value of equity plus market value of equity divided by book value of total assets. In columns (4)-(6), the dependent variable $ROA^{Adj}$, is calculated as adjusted net income before extraordinary items divided by book value of total assets. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

# 4. Conclusions and Future Work

While existing research offers a broad understanding of R&D investment impacts (e.g., Curtis et al., 2020), the financial effects of these investments within the mining industry, characterized by unique fundamentals and high uncertainty, remain underexplored. We provide compelling evidence that R&D investments positively influence investors' perceptions of JMFs, yet further complicate their financial statements, offering new insights for investment decisions and strategic business planning. Second, this study presents the first empirical evidence to evaluate the net economic impact of the Australian R&D Tax Incentive Policy. Therefore, our findings would also be of high importance to national government and regulators as they provide evidence of the effectiveness of the R&D tax regime, with corresponding value to the design and modification of R&D tax incentive schemes in the future. We acknowledge the limitations of our dataset, especially the scarcity of data for channel tests. Future research could significantly benefit from an expanded statistical analysis to uncover more underlying mechanisms between R&D investment and JMFs' financial performance. Additionally, our qualitative results, derived from interviews with management of five JMFs listed on the ASX, should not be generalized to all JMFs internationally. Exploring the applicability of our study's findings to JMFs in other countries presents a promising avenue for future research.

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# 6. References

Aghion, P., & Howitt, P. (1992). A model of growth through creative destruction. *Econometrica*, 60(2), 323-335.

Audretsch, D.B., Segarra, A., & Teruel, M. (2014). Why don't all young firms invest in R&D?. *Small Business Economics*, 43, 751-766.

Curtis, A., McVay, S., & Toynbee, S. (2020). The changing implications of research and development expenditure for future profitability. *Review of Accounting Studies*, 25, 405-437.

Deloitte. (2019). Tracking the Trends: The Top 10 Issues Transforming the Future of Mining.

Eberhart, A.C., Maxwell, W.F., & Siddique, A.R. (2004). An examination of long-term abnormal stock returns and operating performance following R&D increases. *The Journal of Finance*, *59*(2), 623-650.

Ehie, I. C., & K. Olibe. (2010). The effect of R&D investment on firm value: An examination of US manufacturing and service industries. *Int. J. Prod. Econ*., 128(1), 127–135.

Ernst, C., & C. Spengel. (2011). Taxation, R&D tax incentives and patent application in Europe. Centre for European Economic Research, ZEW Mannheim, Discussion Paper, No. 11–024.

Fauver, L., Hung, M., Li, X., & Taboada, A.G. (2017). Board reforms and firm value: Worldwide evidence. *Journal of Financial Economics* 125(1), 120–142.

Hall, B. H. (2020). *Tax policy for innovation*. In Innovation and Public Policy, eidted by A. Goolsbee, and B. Jones, Chapter 5. Chicago, U.S.: University of Chicago Press.

Hall, B. H., J. Mairesse, & P. Mohnen. (2010). *Measuring the returns to R&D*. In Handbook of the Economics of Innovation, edited by B. H. Hall, and N. Rosenberg, 1033-1082. Amsterdam and New York: Elsevier.

Haslam, P.A., & Tanimoune, N.A. (2016). The determinants of social conflict in the Latin American mining sector: new evidence with quantitative data. *World Development*, 78, 401-419.

Heeley, M.B., Matusik, S.F., & Jain, N. (2007). Innovation, appropriability, and the underpricing of initial public offerings. *Academy of Management Journal,* 50(1), 209-225.

Hogan, L, Harman, J, Maritz, A, Thorpe, S, Simms, A, Berry, P, & Copeland, A. (2002). Mineral Exploration in Australia: Trends, Economic Impacts and Policy Issues. *Australian Bureau of Agricultural and Resource Economics*.

Hsu, F.J., Chen, M.Y., Chen, Y.C., & Wang, W.C. (2013). An empirical study on the relationship between R&D and financial performance. *Journal of Applied Finance & Banking*, 3(5), 107-119.

Iddon, C., Hettihewa, S., & Wright, C.S. (2015). Value relevance of accounting and other variables in the junior-mining sector. *Australasian Accounting, Business and Finance Journal*, 9(1), 25-42.

Koh, P.S., Reeb, D.M., & Zhao, W., (2018). CEO confidence and unreported R&D. *Management Science*, 64(12), 5725-5747.

Miller, D., X. Xu, & V. Mehrotra. (2015). When is human capital a valuable resource? The performance effects of Ivy League selection among celebrated CEOs. *Strateg. Manag. J.*, 36(6), 930–944.

Minniti, A., & F. Venturini. (2017). The long-run growth effects of R&D policy. *Research Policy*, 46(1), 316-326

Rafiq, S., Salim, R., & Smyth, R. (2016). The moderating role of firm age in the relationship between R&D expenditure and financial performance: Evidence from Chinese and US mining firms. *Economic Modelling*, 56, 122-132.

Rudenno, V. (2004). *The Mining Valuation Handbook*. 2nd Edition. Wrightbooks, Singapore.

Schilling, M.A. (2015). Technology shocks, technological collaboration, and innovation outcomes. *Organization Science*, 26(3), 668-686.