AUSTRALIAN MINING INDUSTRY: CREDIT AND MARKET TAIL RISK DURING A CRISIS PERIOD

ROBERT POWELL

Edith Cowan University, Australia
E-mail: r.powell@ecu.edu.au

Abstract—Industry risk is important to equities investors in determining portfolio mix. It is also important to lenders in managing credit portfolio risk. This article focuses on the mining industry in Australia, that country's largest industry by exports. The study concentrates on extreme credit and market risk, to determine the riskiness of the mining industry relative to the broader market, with a focus on the Global Financial Crisis (GFC) period and the use tail risk metrics. These include Conditional Value at Risk (CVaR) for measuring market risk and Conditional Distance to Default (CDD) for measuring credit risk. Based on these metrics, the study finds market risk for mining shares to be higher than the broader market, but that the gap narrows during the crisis. From a credit perspective, despite higher volatility experienced by the mining industry, the default risk is lower than the broader market, due to the greater distance between mining entities' asset and debt values.

Index Terms—Conditional Value at Risk,Conditional Distance to Default, Mining, Australia.

I. INTRODUCTION

The Australian mining industry is of critical importance to the Australian economy, especially Western Australia. Indeed, forty-one percent of Australia's total merchandise exports (across all industries) come from Western Australia, and ninety one percent of all Western Australia's merchandise exports are minerals and petroleum [11]. Iron ore is the most significant resource, representing fifty one percent of all Western Australia's resource exports, with seventy nine percent of this going to China. The Australian Mining Industry earns $233 billion annualrevenue [13] .

Given the importance of the mining industry in Australia, this article focuses on mining from a risk perspective to investors (market risk) and lenders (credit risk). In particular, we look at extreme risk, i.e. when investors and lenders are most vulnerable. To isolate extreme risk, the study separately examines the global financial crisis (GFC) period of 2007-2009, but also compares it to pre-GFC and post-GFC periods. Metrics are used which focus on extreme risk. For market risk, Conditional Value at Risk (CVaR) is used, which measures tail risk in share markets beyond a specified threshold. For credit risk, we use our own Conditional Distance to Default Model (CDD), which applies a CVaR type measure to the Merton [16] Distance to Default (DD) model. Results of these metrics are compared to the more usual Value at Risk (VaR) and DD measures.

The study ascertains whether there were key differences in credit and market risk over the periods analysed, and whether the extreme metrics yield additional information than the more traditional measures. Optimisation studies have been undertaken on Australian sectoral risk [5] but as far as the author is aware no analysis has applied all the metrics used in this study specifically to the Australian mining industry, making this study a first. This provides important new information to lenders and investors on extreme risk in this industry in a crisis period.

II. MARKET RISK

Figure 1(a) compares mining shares (represented by the S&P/ASX300 Index which currently includes the 36 largest mining shares on the Australian Securities Exchange) with total Australian shares (represented by Australian All Ordinaries Index, comprising the 500 largest stocks from all industries). The author has common sized the indices to 100 in the year 2000. Mining shares rose much faster than the total market in the 200-2007 period, in line with the 'mining boom' caused by demand from China. These shares fell sharply in the GFC, then rose rapidly again. Mining shares have fallen in more recent years in line with slowing growth in demand from China and a falling iron ore price. It is evident from the graph that an investor in mining shares could receive strong returns in the pre-GFC period and in the GFC recovery period, but that there can be high risk as well, which is the focus of this study.

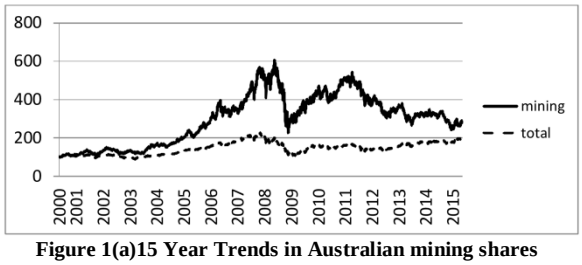

Figure 1(a)15 Year Trends in Australian mining shares

Figure 1(b)Trends in Australian mining shares (GFC)

In Figure 1(b), which isolates the 2007-2009 GFC period (indices common sized to 100 in 2007), the sharper growth and steeper falls of Australian mining stocks is again evident.

This study applies Value at Risk (VaR) and Conditional Value at Risk (CVaR) metrics to market risk. VaR models have become a recognised standard for measuring market risk, particularly since the Basel Accord stipulated them as the standard for measuring market risk in banks. VaR measures potential losses over a specified time period at a selected level of confidence (usually 95% or 99%). Comprehensive discussions on VaR can be found in several papers[8], [10], [12], [14], [15],[20].

A major criticism of VaR, particularly during the GFC, is that it says nothing of the most extreme risk, i.e. those beyond the VaR measure. In this article we will use VaR as a measure of risk, but in order to capture tail risk, we will also use CVaR. CVaR measures those risks beyond VaR. If VaR is measured at 95% confidence level (which we do in this study), then CVaR is the 5% most extreme of observations. Discussions on CVaR can be found in [1] - [3], [6,] [18],[19][21].

Common measures of VaR are the parametric approach which is based on a normal distribution, and the historical simulation approach which is based on actual past observations and makes no assumptions about the distribution. As a normal distribution approach will not tell us anything about the true tail risk, this study uses the historical simulation approach. Under this approach, historical returns are sorted from best to worst and VaR is measured in this study as the actual 95th percentile worst return, with CVaR being the average of the 5% worst returns.

III. CREDIT RISK

As background to the Australian credit risk environment, this study notes that Australian banks are generally considered to have fared very well during the Global Financial Crisis. Banks remained profitable and there were no bank failures. Nonetheless, credit risk did increase substantially, but to a much lesser extent than that seen globally. Of course, not all industries fare equally during a crisis and the examination of credit risk in this study provides important information on the resilience of the mining industry in a crisis period.

The study uses the Merton Distance to Default (DD) model to calculate credit risk, as described in [9]. As the model is well known, we will only describe it briefly here. The approach follows on from the work of Black and Scholes in 1973. The assumption is made that the firm has a single debt and single equity issue. The debt (F) comprises a zero coupon bond that matures at time (T) at which stage the firm repays the bond and the balance is distributed to the shareholders. If debt exceeds the asset values (V), then the firm defaults. This is the same as the payoff of a call option on the firm's value. If assets exceed loans at point T, the owners will exercise the option to repay the loans and keep the liability. Probability of Default PD is a function of the Distance to Default DD (number of standard deviations between the value of the firm and the debt) determined using the market value of assets (A), the debt (F) and the volatility of assets σ_V. Asset volatilities are calculated as a function of equity values and liabilities using an iteration and convergence procedure, as outlined in [4], [7]. Merton assumes that asset values are log normally distributed, as shown in equation 1 where μ is an estimate of the annual return (drift) of the firm's assets.

$$DD = \frac{\ln(V/F) + (\mu - 0.5\sigma_V^2)T}{\sigma_V \sqrt{T}} \qquad (1)$$

This study applies the author's own CVaR type measure to the above equation, which is called CDD (Conditional Distance to Default), where σ_V in equation 1 substituted with the volatility applying to the worst 5% of asset value returns.

IV. DATA AND METHOD

The study compares entities in the Mining industry to the total of all industries. For total industries, the All Ords index is used, which comprises the 500 largest entities by market cap and represents approximately 90% of all entities on the Australian Share market (ASX). Equity returns (daily time series data), together with the balance sheet data required for calculating DD and CDD, are obtained from DataStream. Entities which do not have sufficient data covering the full analysis period are eliminated. Our final sample represents approximately 90% of All Ords entities, of which mining shares are approximately 17%.

While the study focuses on the GFC period (three years from 2007-2009), it also compares this period to a pre-GFC period (three years from 2004-2006) and a post-GFC period (three years from 2010-2012). Market risk is calculated using the VaR and CVaR measures, and credit risk using DD and CDD, as previously explained. These metrics are calculated for each individual entity as well as for the portfolio as a whole. In calculating portfolio risk, correlations are applied to the daily equity values (VaR and CVaR) and daily asset values (DD and CDD), using usual historical VaR correlation methodology as described in [8]. VaR, CVaR, DD and CDD are calculated for each year from the daily values, as well as for each of the three periods (pre-GFC, GFC and post-GFC).

F tests for significance in volatility differences are applied to each metric to determine differences between the mining industry and the total market.

V. RESULTS

A. VaR and CVaR Results

The results are presented in Figure 2. Fifteen years are shown. Both the VaR and CVaR graphs show that

mining volatility is higher than that of the total of all combined industries, for nearly all of the years up to 2009, with the gap narrowing thereafter. The spike over the GFC period is clearly evident. Both axes are set to the same scale, so the higher risk associated with CVaR is clearly evident.

Also evident is the narrowing of the gap in 2009 and 2010, with the mining industry recovering much quicker from the crisis as evidenced by Figure 1, with strong resources demand from China, particularly for iron ore.

In Table 1, figures for the three year GFC period (2007-2009) have been compared to a pre-GFC period (the three years before the GFC) and a post-GFC period (the three years following the GFC). The figures show daily VaR (the maximum percentage daily loss in 95% of cases) and daily CVAR (the average percentage daily loss in the worst 5% of cases).

It is interesting to note, that while mining is still more volatile than the total during the GFC, the gap narrows. This is because while mining was already a fairly volatile industry pre-GFC, all industries became highly volatile during the GFC (especially the previously stable financial industry), thus narrowing the VaR gap between mining and total. Also while mining fell heavily in the GFC, as seen in Figure 1, the fall commenced later and the climb sooner than the total market. Indeed if we isolate year 2008 only, the mining to total ratio increased to 1.4, but was close to 1.0 for 2007 and 2009 (and thereafter periods). Thus the volatility increased more than the market at the height of the crisis, but mining had a shorter crisis than the market. The higher volatility of the mining industry is significant at the 99% level for all periods except the post-GFC period.

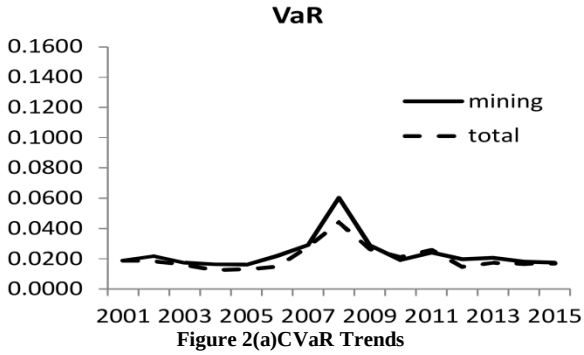

Figure 2(a)CVaR Trends

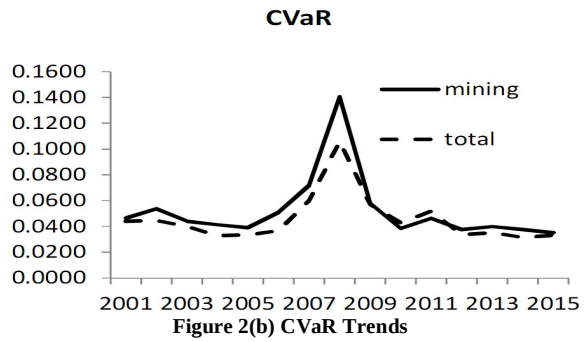

Figure 2(b) CVaR Trends

In Table 1, ** denotes significant differences between mining and total at the 99% significance level, and * at the 95% level, using an F test for measuring differences in volatility, which is applied to volatility in daily equity values.

Table 1 VaR and CVaR Results

VaR	Mining	Total	Ratio Mining to Total
Pre GFC	0.0181	0.0134	1.35**
GFC	0.0394	0.0328	1.20**
Post GFC	0.0210	0.0206	1.02

CVaR	Mining	Total	Ratio Mining to Total
Pre GFC	0.0438	0.0343	1.28**
GFC	0.0901	0.0744	1.21**
Post GFC	0.0407	0.0427	0.95*

Ratio CVaR to VaR	Mining	Total
Pre GFC	2.42	2.55**
GFC	2.29	2.27**
Post GFC	1.94	2.07**

B. DD and CDD Results

It is evident from Figure 3, that for the most part, DD and CDD for mining are not any worse than the market. This is despite the higher volatility demonstrated by the prior VaR and CVaR discussion. This is because volatility is only one part (the denominator) of the equation. The other part is the distance between the market value of assets and the liabilities. As seen in Figure 1, the value of mining shares (based on a common index) has always been above those of the market. As market equity influences asset values, this increases the distance to default. At times, the mining default risk is lower than the market, especially when mining made a much faster recovery from than the GFC than the broader market.

It is evident from the ratio of DD for mining to that of the total market, as shown in Table 2, that DD for mining has been similar to that of the market for the pre-GFC and GFC periods. Mining's quick and sharp recovery out of the GFC has seen the DD increase (i.e. reduced risk) above that of the market (by 1.3 times). From a CDD perspective, default risk is even wider during the GFC and thereafter, given mining's shorter crisis and quicker recovery, meaning the market had a more prolonged period of extreme risk, and a larger gap between DD and CDD. There is no significant difference in DD between the mining industry and the total market pre-GFC, while CDD has a difference which is only significant at the 95% level. In the GFC period, DD is not significantly different between mining and total, while CDD is significantly better for mining. Given that CDD is the most extreme credit measure in this analysis and that the GFC is the most extreme period, this means that that credit risk was

lower for mining than for total industries at the most extreme point of our analysis. In the post-GFC period, DD and CDD are both significantly better for mining.

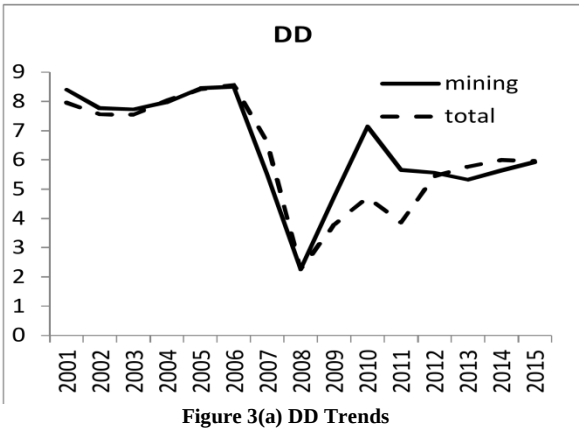

Figure 3(a) DD Trends

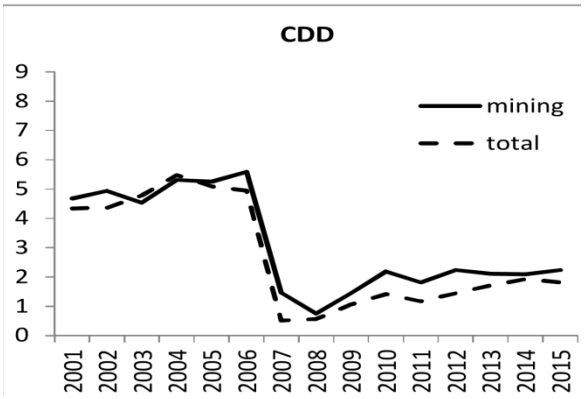

Figure 3(b) CDD Trends

In Table 2, ** denotes significant differences between mining and total at the 99% significance level, and * at the 95% level, using an F test for measuring differences in volatility.

Table 2 DD and CDD Results

DD	Mining	Total	Ratio Mining to Total
Pre GFC	8.3093	8.3367	1.00
GFC	4.1673	4.2214	0.99
Post GFC	6.1209	4.6743	1.31**

CDD	Mining	Total	Ratio Mining to Total
Pre GFC	5.3845	5.1704	1.04*
GFC	1.2204	0.7134	1.71**
Post GFC	2.0823	1.3408	1.55**

Ratio DD to CDD	Mining	Total
Pre GFC	1.54	1.61**
GFC	3.41	5.92**
Post GFC	2.94	3.49**

CONCLUSION

This article set out to examine the market and credit risk of the mining industry in Australia as compared to the broader market, with a focus on extreme risk. The GFC period was isolated and compared to pre-and post-GFC periods. In addition, CVaR and CDD metrics were used to measure extreme risk, in addition to the more usual VaR and DD measures. The study showed that market risk for mining shares, as measured by VaR and CVaR is for the most part, significantly higher than that of the broader market. Thus, while investors are able to generate higher returns from mining shares, they also face higher risk. This gap narrowed during the crisis period with mining having a much shorter crisis and steeper recovery than the market.

Despite the higher volatility, and higher risk from an investor perspective, there was no evidence of higher credit risk, with mining entities, especially as measured by CDD, having for the most part of the period investigated, a significantly lower default risk than the market, due to the larger distance between market asset values and debt. The study thus showed that extreme measures such as CDD can give important information which can be missed when using traditional measures such as DD, given the much bigger gap between mining and the broader market (favouring mining) for CDD than for DD in the GFC period.These findings provide important information to Australian investors and lenders when considering the inclusion of mining entities in their investment or loan portfolios.

REFERENCES

[1] G. J.Alexander and A. M.Baptista, “CVaR as a measure of risk: Implications for portfolio selection”, Working paper, School of Management, University of Minnesota, 2003.

[2] S. Alexander, T. F. Coleman and Y. Li, “Derivative portfolio hedging based on CVaR, in G. Szego Ed., New risk measures in investment and regulation, Wiley, 2003.

[3] D. E. Allen, R. J. Powell and A. K.Singh, “Take it to the limit: Innovative CVaR applications to extreme credit risk measurement”, in Press, European Journal of Operational Research, 2014.

[4] D. E. Allen andR. J. Powell, “Structural credit modelling and its relationship to market value at risk”: An Australian sectoral perspective. In G. N. Gregoriou Ed., The VaR implementation handbook, McGraw Hill, New York, , pp. 403-414,2009.

[5] D. E. Allen, R. J. Powell, “Measuring and optimising extreme sectoral risk in Australia”, Asia Pacific Journal of Economics and Business, vol. 15, no. 1, pp. 1-14,2011.

[6] F. Andersson, H. Mausser, D. Rosen and S. Uryasev, “Credit risk optimization with conditional value-at risk criterion”, Mathematical Programming, vol. 89, no. 2, pp. 273-291,2000.

[7] S. Bharath and T. Shumway, “Forecasting default with the Merton Distance-to-Default model”. The Review of Financial Studies, vol. 21, no.3, pp.1339-1369, 2008.

[8] Y. H. Cheung andR. J. Powell, “Anybody can do Value at Risk: Demystifying nonparametric computation. Australasian Accounting, Business and Finance Journal, vol. 6, no. 1, pp.111-123.

[9] P. Crosbie andJ. Bohn, 2003. “Modelling default risk”,retrieved 12 Feb 2014. Available at www.moodysanalytics.com.

[10] D. Duffie andJ. Pan, "An overview of Value at Risk". Journal of Derivatives, vol. 4, no. 3, pp. 7-49., 1997.
[11] Government of Western Australia Department of Mines and Petroleum, Statistics Digest, 2014. Retrieved 1 May 2015, Available at http://www.dmp.wa.gov.au/1088.aspx.
[12] G.N. Gregoriou, The VaR implementation handbook, McGraw Hill, New York, 2009,
[13] IBISWorld, "Mining in Australia", 2015.
[14] J.P. Morgan, & Reuters. RiskMetrics Technical Document, 1996.
[15] P. Jorion, "Value at Risk: The new benchmark for controlling derivative risk", Irwin Professional Publishing, 1996.
[16] R. Merton, "On the pricing of corporate debt: The risk structure of interest rates", Journal of Finance, vol. 29, pp. 449-470.
[17] R. J. Powelland D.E. Allen "CVaR and credit risk management", 18th World IMACS Congress and MODSIM09 International Congress on Modelling and Simulation, Cairns, pp. 1508-1514,July 2009.
[18] R. T. Rockafellar and S. Uryasev, "Conditional Value-at-Risk for general Loss distributions", Journal of Banking and Finance, 26, 7, 2002, p1443-1471.
[19] R.T. Rockafellar, S. Uryasev andM. Zabarankin, "Master funds in portfolio analysis with general deviation measures", Journal of Banking and Finance, vol. 30, no. 2, pp. 743-776.2006
[20] F. Stambaugh, "Risk and Value at Risk", European Management Journal, vol. 14, no. 6, pp.612-621, 1996.
[21] S. Uryasev andR.T. Rockafellar, "Optimisation of Conditional Value-at-Risk", Journal of Risk, vol. 2, no. 3, pp. 21-41,2000.

★★★