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Regular article

Not all gold shines in crisis times — Gold firms, gold bullion and the COVID-19 shock

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A B S T R A C T

This paper analyses the impact of the coronavirus pandemic on the share prices of three different types of gold firms — explorers, developers and producers. Despite the fundamental link of these companies to gold price movements and gold’s relative strength during the COVID outbreak, we find a COVID-induced decoupling of gold companies from the price of gold illustrating that gold shares are exposed to market risk and not a safe haven. The equity market and gold exposures differ systematically between explorers, developers and producers in normal times but are higher and more similar in crisis times. Our findings demonstrate that investors treat gold companies differently in normal times and more equally in crisis times implying temporary mispricing and profit opportunities.

1. Introduction

Interest in gold and in gold equities as a potential safe haven investment has heightened during the COVID-19 period. For example, Warren Buffett’s Berkshire Hathaway recently announced holding a $500 m stake in gold mining company Barrick Gold. 2 For gold itself, in Australia, the combination of a strong US dollar gold price with a relatively weak Australian dollar (A$) resulted in record A$ gold prices in nominal terms - a result of gold’s currency hedge property. For gold equities, the situation is more complex. Gold equities are not commodities, as the business activities and assets of each firm differ from the next. Gold equities encompass explorers (approx. A$10 m to A$100 m capitalisation), developers (approx. A$100 m to A$1 billion) and miners (approx. A$1 billion to A$10 billion). Since gold company revenues are based on the sale of gold, gold equities are linked to gold prices, i.e. if the price of gold goes up, gold company share prices will also go up and if the price of gold goes down, gold company share prices will also go down. However, gold equities (shares) are also related to the equity (share) market which can alter the co-movement with gold. This market exposure may be hidden in normal times, but be very prominent in crisis times. Hence, the severity of the COVID-19 market shock provides a unique opportunity to unpick the link of gold companies to the gold price and to the market. Specifically, this paper uses the COVID-19 shock to study the links of different types of gold companies to gold bullion and to the market in normal times and during the COVID-19 crisis time.

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2 "Warren Buffett’s Berkshire Hathaway Joins the Gold Rush", Wall Street Journal, August 17, 2020.

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The econometric analysis uncovers the following relationships: gold firms are differently exposed to the market and the gold price in normal times (producers more to gold and less to the market and explorers less to gold and more to the market consistent with the higher risk of these companies) but more exposed and more similarly exposed during the initial phase of the pandemic.

The results indicate that investors distinguish between explorers, developers and producers in normal times but less so in crisis times. In crisis times, the market dominates because the magnitude of the market shock is much larger (e.g. -20%) than the magnitude of the gold shock (e.g. +5%). As a consequence, gold equities were not immune but severely affected by the COVID-19 market shock.

The decoupling of gold shares from the price of gold shows that the market exposure can be contagious if the shock is sufficiently large. Hence, a crisis-induced decoupling implies that fundamentals represented by future expected cashflows are temporarily less important than uncertainty and risk aversion captured by the discount rate, which can explain the sharp decline in share prices. The contagious similar adverse impact of the market on all different types of gold shares suggests that fundamentals were not the main source. However, the decoupling of gold shares also means that there is an expected recoupling to realign valuations with the price of gold in the future and presents an arbitrage and profit opportunity for investors.

The literature on gold mining shares dates back to Faff and Chan (1998), Twite (2002), Baur (2011, 2014) and, more recently (Jensen et al., 2018). The closest research to this paper is a study by Baur et al. (2020) who analyse the performance of the largest gold shares traded on the Australian, Canadian, UK and US stock markets for major economic and financial crisis but excluding the COVID-19 crisis and not distinguishing between types of gold firms, i.e. between explorers, developers and miners. The paper further contributes to the literature on the role of gold as a currency hedge (e.g. see Capie et al. (2005), Reboredo (2013), Reboredo and Rivera-Castro (2014)), as a safe haven (Baur and Lucey (2010) and Baur and McDermott (2010)) and to gold mining in general (e.g. Tufano (1996, 1998) and Adam et al. (2017)).

More recent literature on COVID and safe havens are Akhtaruzzaman et al. (2020), Cheema and Szulczuk (2020), Conlon and McGee (2020), Corbet et al. (2020) and Ji et al. (2020) among others. It is important to note that this paper is primarily about gold and gold shares during COVID and not about safe havens in general.

Our paper is also related to the literature on financial contagion (e.g. see Baig and Goldfajn (1999), Forbes and Rigobon (2002) and Pericoli and Sbracia (2003)) as we analyse the contagious impact of the COVID-19 market shock on gold shares. However, this study is different to the “traditional” contagion literature in that the focus is not on financial contagion in international equity markets but on financial contagion in a specific equity market — the market for gold companies. The analysis is more narrow but also deeper because we analyse different risk characteristics of firms (high-risk explorers versus medium-risk developers and lower-risk gold miners) and changes in the interdependence of gold shares with the overall equity market, with gold and with other gold mining firms. In other words, our framework is more granular and analyses contagion from the broader equity market to the gold equity market and contagious effects within that gold equity market. We also analyse the role of gold prices in US$ and A$ and thus relate the role of gold prices denominated in different currencies to the well-established currency hedge property of gold. This property is important as it can result in falling gold prices denominated in US$ and rising gold prices denominated in A$ if the US$ appreciates significantly. In other words, gold’s safe haven property may be conditional on the currency in which it is denominated.

The rest of the paper is structured as follows. Section 2 describes the types of gold firms and the data. Section 3 presents the empirical analysis based on a panel model. Section 4 summarises the main findings and concludes.

2. Data and descriptive analysis

Data

We identify 226 ASX-listed companies across the value chain where the principal business focus is gold. The companies are classified by their business activity as gold miners (29 companies), gold project developers (23 companies) or gold explorers (163 companies). The list of firms (company names) is presented in Table 7 in the Appendix. We retrieve daily share price data of these companies from Thomson Reuters Datastream from January 1, 2017 to March 15, 2021.

Gold firms

Gold mining companies are defined as having already commenced gold production from one or more operating mines. Gold project development companies are defined as having already delineated significant in-ground gold resources but who have yet to commence gold production. That is, project development companies are undertaking a stage-gated evaluation process to evaluate the economics of future gold production. No distinction was drawn as to the relative stage of project assessment — early-stage (e.g. scoping level study), mid-stage (e.g. feasibility studies) or late-stage (e.g. Final Investment Decision and construction). Gold exploration companies comprise those companies holding exploration licences and with clear intent to discover and delineate gold deposits. No distinction was drawn as to the relative stage of gold exploration — early-stage (e.g. licence application and remote targeting), mid-stage (e.g. field-sampling and active drill-testing) or late-stage (e.g. discovery and delineation of gold resources). We consider this three-fold classification to be insightful, but unlike gold, gold equities themselves are not standardised in their

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3 This conclusion is based on the assumption that mining operations are not materially affected by COVID-19 (see Jowitt (2020)).
4 Global trends in gold mining are analysed in Mudd (2007a,b).
5 This implication is also reflected in the title of this paper “Not all gold shines in crisis times”.

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composition. Indeed, no two gold companies are exactly the same. ASX-listed gold mining companies may operate in Australia (e.g. Pantoro, Ramelius Resources, Regis Resources) or also own gold mines internationally (e.g. Northern Star Resources, St Barbara Mines). Gold mines can be open pit, underground developments or developed as a combination of the two. The grade of gold that is mined can vary tenfold, for example from less than 1 gram per tonne of rock to over 10 grams per tonne of rock (Ulrich et al., 2019). Gold mining companies also have different balance sheets, capital costs, operating costs (All-In-Sustaining-Costs, AISC, Gianfrate (2017)), currency exposure, production scale (Guj, 2011), hedge books (Tufano (1998) and Fang et al. (2007)), in-ground reserves or resources (Ulrich et al., 2019) and vastly different environmental footprints (including Greenhouse Gas Emissions, Mudd (2007a) and Ulrich et al. (2020)).

Similarly, gold project development companies may be Australian (e.g. Bellevue Gold, Western Australia) or internationally-focused (e.g. Big River Gold, Brazil; Geopacific Resources, Papua New Guinea), hold gold projects with varying capital requirements, forecast costs, lead-times, socioeconomic impacts and production scale (Ferguson et al., 2011). Furthermore, some gold assets contain just gold, whereas others have payable co-products (e.g. gold and copper) or by-product credits (e.g. silver).

Gold exploration companies too are non-standardised (e.g. Kreuzer et al. (2007)). We highlight the different stages of gold exploration above, the degree to which gold explorers have discovered in-ground gold as either resources or reserves, but many other differences also exist between exploration companies. For example, explorers may be active in one or more jurisdictions (e.g. Arrow Minerals in Burkina Faso & Australia), with some geographies ranked as more risky than others (Stedma et al., 2019). Some explorers are solely gold-focused, whereas other explorers hold leases that are prospective for both gold and for other commodities (e.g. for gold, nickel and lithium in the Western Australian goldfields). Gold explorers also differ in their level of cash reserves and in enterprise values. Finally, gold exploration assets may be either wholly-owned by a single company, or else explored under joint venture agreements with one or more partner companies (e.g. Guj (2011), Guj et al. (2011) and Ulrich et al. (2020)).

Descriptive analysis

Table 1 presents the descriptive statistics of daily share price returns for the full sample period, a pre-crisis period and a COVID crisis period. We use the Wuhan lockdown (24/1/2020) as the start of the COVID crisis period and assume this crisis to last until 30/4/2020. The pre-crisis period is of equal length. We define the crisis period as a stock market crisis related to COVID and not as a more general COVID crisis as this pandemic is ongoing at the time of writing. The graphical analysis below shows that the relatively short crisis period definitions fully captures the severity of the COVID outbreak on stock markets.

Fig. 1 shows the relative market performance of the different types of gold companies to the gold price and ASX100 in the years leading up to the COVID-19 pandemic. Since 2017, the average performance of gold producers materially outperformed gold developers, who in turn outperformed gold explorers. That is, despite the strong performance of the gold price, rising over the period, the market support for the different types of gold companies decoupled. Gold producers, earning cashflows from mining, performed best, but still underperformed gold itself. Gold developers had no such cashflow buffer, and were thus reliant upon sourcing project debt and new equity (at lower prices) in their pursuit of new production. Finally gold explorers were particularly hard-hit in the
pre-COVID period, on average falling by over 50%, despite a rising gold market. In the absence of cashflow or asset sales, such companies required ever-lower, diluting, equity raisings to continue exploration for gold.

Fig. 2 zooms into the COVID period and presents gold prices denominated in US dollars and Australian dollars. The plots demonstrate why gold is a currency hedge. Since the Australian dollar depreciated relative to the US dollar during the initial phase of the pandemic, the gold price in Australian dollar increased relative to the US dollar price of gold.\(^6\)

The gold prices in US$ also show a rather unique pattern for gold. While gold was relatively stable and did not fall in tandem with the stock market initially, it eventually fell and appears to have been pulled down by the market. It has been argued that this is evidence that gold lost its safe haven status. However, the gold price denominated in A$ did not fall which is inconsistent with the claim that gold lost its safe haven status.

The performance of the various types of gold companies during the pandemic is in marked contrast to the preceding period. Strikingly, the market performance of gold producers, gold developers and gold explorers in the COVID-19 crisis is relatively similar compared with the pre-crisis performance. Decoupling from the gold price is clearly evident and relatively uniform across gold companies, i.e. gold companies of all types performed in line with the broader ASX200 market. The exposure of gold companies to the equity market dominated over their linkage to the gold price, whether measured in US$ (Panel (a) in Fig. 2) or in the local A$ (Panel (b) in Fig. 2).

Fig. 3 displays the performance over an extended post-shock period and illustrates that producer prices reversed its losses and converged toward the price of gold while explorer and developer prices fully recouped their losses and clearly outperformed producer prices and the price of gold.

Since gold prices in A$ increased by more than gold prices in US$, the decoupling of gold firms from the prevailing A$ gold price is larger than from the US$ gold price as shown in Fig. 4.

The distribution of firm-specific (unconditional and raw) performances over the full period, the immediate pre-COVID period and the COVID period are presented graphically in Fig. 5. The densities illustrate different average returns and distributions across the three types of firms in normal times but more similar average returns and distributions in the COVID period.

3. Econometric analysis

3.1. Methodology

To identify the exposure of gold firms to changes of the price of gold and the market, we start with a simple model that assumes that the exposure is constant over time and equal across firms. The model is given as follows:

\[
R_{i,t} = a_i + \beta_0 R_{M,t} + \gamma_0 R_{G,t} + \epsilon_{i,t}
\]

\(^6\) Since gold is traded globally, the relationship of gold prices with the value of currencies is negative. For example, a falling US dollar increases the price of gold in US$ (all else equal) and a falling Australian dollar increases the price of gold in A$ (all else equal).
In a next step we allow different exposures during the COVID-19 crisis captured by the dummy variable $\text{COVID}$ as specified by the following equation

$$R_{i,t} = \alpha_i + \beta_0 R_{M,t} + \beta_1 R_{M,t} \text{COVID} + \gamma_0 R_{G,t} + \gamma_1 R_{G,t} \text{COVID} + \epsilon_{i,t} \quad (2)$$

and different exposures across gold firm types (explorers, developers and producers) as specified by the following equation

$$R_{i,t} = \alpha_i + \beta_0 R_{M,t} + \sum_{j=1}^{3} \beta_{2,j} R_{M,t} \text{firm type}_j +$$
We define the COVID-19 crisis period from January 24, 2020 to April 30, 2020 but also entertain different starting points (e.g. February 24, 2020), shorter and longer crisis period lengths.

Finally, we combine Eqs. (2) and (3) into one large model as follows

\[
R_{i,t} = \alpha_i + \beta_{0,i}R_{M,t} + \beta_{1,i}R_{M,t}D_{COVID} + \\
+ \sum_{j=1}^{3} \beta_{2,i,j}R_{M,t}D_{firm type,j} + \sum_{j=1}^{3} \beta_{3,i,j}R_{M,t}D_{firm type,j}D_{COVID} + \\
+ \gamma_{0,i}R_{G,t} + \gamma_{1,i}R_{G,t}D_{COVID} + \\
+ \gamma_{2,i}R_{G,t} + \gamma_{3,i}R_{G,t}D_{COVID} + \\
+ \gamma_{4,i}R_{G,t}D_{COVID} + \\
+ \gamma_{5,i}R_{G,t}D_{COVID} + \\
+ \epsilon_{i,t}
\]
Fig. 5. Histograms of Average (raw) Returns for all firms over the full sample period, the pre-COVID period and the COVID period for Explorers, Developers and Producers.
Table 2
Estimation results: Gold denominated in US$.

| Dependent variable: gold share returns | (1)         | (2)         | (3)         | (4)         |
|----------------------------------------|-------------|-------------|-------------|-------------|
| Market                                 | 0.349***    | 0.305***    | 0.176***    | 0.192**     |
|                                        | (0.014)     | (0.020)     | (0.061)     | (0.090)     |
| Dtype1                                 | 0.195***    | 0.214***    | 0.176***    | 0.192**     |
|                                        | (0.070)     | (0.072)     | (0.061)     | (0.090)     |
| Dtype2                                 | 0.211**     | 0.231***    | 0.176***    | 0.192**     |
|                                        | (0.082)     | (0.085)     | (0.061)     | (0.090)     |
| Dtype3                                 | 0.233***    | 0.239***    | 0.176***    | 0.192**     |
|                                        | (0.079)     | (0.082)     | (0.061)     | (0.090)     |
| gold                                   | 0.274***    | 0.213***    | 0.255***    | 0.168*      |
|                                        | (0.018)     | (0.020)     | (0.079)     | (0.089)     |
| market X D                             | 0.049*      | -0.126      |             |             |
|                                        | (0.028)     |             |             |             |
| gold X D                               | 0.268***    | 0.523**     |             |             |
|                                        | (0.046)     |             |             |             |
| market X Dtype1                         |             | 0.194***    |             | 0.119       |
|                                        |             | (0.063)     |             | (0.093)     |
| market X Dtype2                         |             | 0.156**     |             | 0.156       |
|                                        |             | (0.075)     |             | (0.110)     |
| market X Dtype3                         |             | 0.142**     |             | 0.098       |
|                                        |             | (0.072)     |             | (0.106)     |
| gold X Dtype1                           |             | 0.010       |             | 0.033       |
|                                        |             | (0.082)     |             | (0.092)     |
| gold X Dtype2                           |             | 0.013       |             | 0.067       |
|                                        |             | (0.097)     |             | (0.110)     |
| gold X Dtype3                           |             | 0.084       |             | 0.112       |
|                                        |             | (0.093)     |             | (0.105)     |
| market X Dtype1 X D                    |             |             |             | 0.201       |
|                                        |             |             |             | (0.135)     |
| market X Dtype2 X D                    |             |             |             | 0.070       |
|                                        |             |             |             | (0.158)     |
| market X Dtype3 X D                    |             |             |             | 0.166       |
|                                        |             |             |             | (0.153)     |
| gold X Dtype1 X D                      |             |             |             | -0.251      |
|                                        |             |             |             | (0.219)     |
| gold X Dtype2 X D                      |             |             |             | -0.342      |
|                                        |             |             |             | (0.256)     |
| gold X Dtype3 X D                      |             |             |             | -0.266      |
|                                        |             |             |             | (0.248)     |

Observations 237,888 237,888 237,888 237,888

\[ R^2 \] 0.004 0.004 0.004 0.004

Adjusted \[ R^2 \] 0.003 0.003 0.003 0.003

\[ F \text{ Statistic} \] 476.887*** (df = 2; 237660) 199.811*** (df = 5; 237657) 88.719*** (df = 11; 237651) 44.776*** (df = 23; 237639)

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

We use a pooled OLS and fixed-effects (FE) model to estimate the parameters of all models but also estimate models 1 and 2 (Eqs. (1) and (2)) individually for each firm for robustness. Furthermore, we construct equally-weighted portfolios comprised of all explorers, all developers and all producers as an alternative to the panel data models.

Models 2 and 4 allow to test for an increased exposure to the market consistent with contagion from the market. More specifically, we can test whether the market exposure during the crisis increases implying contagion from the stock market. Such contagion also reduces or eliminates any potential safe haven effects as strong exposures to the market imply that firms are pulled down by the market and thus away from the gold price.
### Table 3
Estimation results: Gold denominated in A$.  

| Dependent variable: | (1) | (2) | (3) | (4) |
|---------------------|-----|-----|-----|-----|
| **gold share returns** |     |     |     |     |
| Market              | 0.447*** | 0.380*** | 0.283*** | 0.248*** |
|                     | (0.014)  | (0.020)  | (0.063)  | (0.092)  |
| Dtype1              | 0.191*** | 0.207*** | 0.223*** | 0.238*** |
|                     | (0.070)  | (0.072)  | (0.085)  | (0.082)  |
| Dtype2              | 0.209**  | 0.231*** | 0.238*** | 0.323*** |
|                     | (0.082)  | (0.079)  | (0.082)  | (0.091)  |
| Dtype3              | 0.231*** | 0.223*** | 0.121    | 0.448**  |
|                     | (0.079)  | (0.072)  | (0.128)  | (0.199)  |
| gold                | 0.440*** | 0.423*** | 0.419*** | 0.323*** |
|                     | (0.018)  | (0.019)  | (0.081)  | (0.091)  |
| Market X Dtype1     | 0.183*** | 0.141    |       |     |
|                     | (0.065)  | (0.095)  |       |     |
| Market X Dtype2     | 0.121    | 0.168    |       |     |
|                     | (0.077)  | (0.112)  |       |     |
| Market X Dtype3     | 0.159**  | 0.104    |       |     |
|                     | (0.074)  | (0.108)  |       |     |
| gold X Dtype1       | 0.021    | 0.110    |       |     |
|                     | (0.083)  | (0.094)  |       |     |
| gold X Dtype2       | −0.079   | 0.068    |       |     |
|                     | (0.097)  | (0.109)  |       |     |
| gold X Dtype3       | 0.111    | 0.106    |       |     |
|                     | (0.094)  | (0.106)  |       |     |
| market X D Dtype1   |       |       | 0.029 |     |
|                     |       |       | (0.132) |     |
| market X D Dtype2   |       | −0.174  |       |     |
|                     |       | (0.156) |       |     |
| market X D Dtype3   |       | 0.107   |       |     |
|                     |       | (0.150) |       |     |
| gold X D Dtype1     |       | −0.424**|       |     |
|                     |       | (0.206) |       |     |
| gold X D Dtype2     |       | −0.746***|       |     |
|                     |       | (0.247) |       |     |
| gold X D Dtype3     |       | 0.071   |       |     |
|                     |       | (0.236) |       |     |
| Observations        | 237,888 | 237,888 | 237,888 | 237,888 |
| $R^2$               | 0.006   | 0.006   | 0.006   | 0.006   |
| Adjusted $R^2$      | 0.005   | 0.005   | 0.005   | 0.005   |
| $F$ Statistic       | 675.012*** (df = 2; 237660) | 274.939*** (df = 5; 237657) | 125.021*** (df = 11; 237651) | 62.096*** (df = 23; 237639) |

*Note: * $p < 0.1; ** p < 0.05; *** p < 0.01.

As a robustness check and an additional analysis we also study changes in the correlation of the assets in the crisis period relative to the pre-crisis periods to identify contagion (e.g. see Baig and Goldfajn (1999), Forbes and Rigobon (2002)) between the gold companies and the market, and among gold companies.

### 3.2. Estimation results

This section presents the estimation results based on Eqs. (1)–(4). We first present and discuss the simpler and constrained models based on Eqs. (1)–(3) followed by the unconstrained model based on Eq. (4). The correlation estimates for the pre-COVID sample and the COVID sample are presented as an additional analysis in Table 4.
Table 4
Correlations.

Panel A: pre-crisis period

|     | exp | dev | pro | ASX200 | Gold in US$ | Gold in A$ |
|-----|-----|-----|-----|--------|-------------|------------|
| exp | 1   | 0.29| 0.19|       | 0.27        | 0.24       |
| dev | 1   | 0.45| 0.00| 0.01   | 0.21        | 0.45       |
| pro | 1   |     |     | −0.06 | 0.27        | 0.71       |
| ASX200 | 1     | −0.16|   | −0.01 |            |            |
| Gold in US$ | 1     |      |     | 0.23  |            |            |
| Gold in A$ |       |     |     |       |            |            |

Panel B: crisis period

|     | exp | dev | pro | ASX200 | Gold in US$ | Gold in A$ |
|-----|-----|-----|-----|--------|-------------|------------|
| exp | 1   | 0.85| 0.76| 0.49   | 0.39        | 0.06       |
| dev | 1   | 0.83| 0.58| 0.41   | 0.06        |            |
| pro | 1   | 0.47| 0.54| 0.22   |             |            |
| ASX200 | 1     | 0.35|   | −0.33 |            |            |
| Gold in US$ | 1     |      |     |       |            |            |
| Gold in A$ |       |     |     |       |            |            |

Panel C: Δ (crisis–pre-crisis)

|     | exp | dev | pro | ASX200 | Gold in US$ | Gold in A$ |
|-----|-----|-----|-----|--------|-------------|------------|
| exp | 0.56| 0.57| 0.50| 0.12   | −0.18       |            |
| dev | 0.38| 0.58| 0.20|       | −0.39      |            |
| pro | 0.53| 0.27| 0.49|       |            |            |
| ASX200 | 0.51|      | 0.32|       |            |            |
| Gold in US$ |      |     |     | −0.08  |            |            |
| Gold in A$ |       |     |     | 0.00   |            |            |

Note: Crisis period: 24/1/2020 (Wuhan lockdown) - 30/4/2020, pre-crisis 21/10/2019–23/1/2020 different correlation matrix equality tests (Steiger test, Jennrich test) yield highly significant (p-values smaller than 1%) differences in pre-crisis and crisis correlations.

Table 5
Estimation results for portfolios of explorers, developers and producers.

|     | P1  | P2  | P3  | P1  | P2  | P3  |
|-----|-----|-----|-----|-----|-----|-----|
|     | (1) | (2) | (3) | (4) | (5) | (6) |

Dependent variable:

|     | Market | goldUS$ | goldA$ | Constant | Observations | R² | Adjusted R² | Residual Std. Error (df = 1093) | F Statistic (df = 2; 1093) |
|-----|--------|---------|--------|----------|--------------|----|-------------|----------------------------------|---------------------------|
|     | 0.322*** | 0.492*** | 0.256*** | 0.406*** | 0.645*** | 0.502*** | (0.037)  | (0.057)  | (0.054)  | (0.038)  | (0.057)  | (0.051)  | (0.049)  | (0.074)  | (0.070)  | 0.380*** | 0.693*** | 1.117*** | (0.047)  | (0.071)  | (0.064)  |
| goldUS$ | 0.248*** | 0.433*** | 0.693*** | (0.049)  | (0.074)  | (0.070)  |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| goldA$ |          |         |        |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Constant | 0.001  | −0.004   | 0.055  | −0.002  | −0.011  | 0.043  | (0.040)  | (0.061)  | (0.058)  | (0.040)  | (0.060)  | (0.054)  |          |          |          |          |          |          |          |          |
| Observations | 1,096  | 1,096  | 1,096  | 1,096  | 1,096  | 1,096  |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| R² | 0.089  | 0.097  | 0.104  | 0.119  | 0.144  | 0.237  |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Adjusted R² | 0.087  | 0.095  | 0.102  | 0.118  | 0.142  | 0.235  |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| Residual Std. Error (df = 1093) | 1.334  | 2.022  | 1.928  | 1.312  | 1.969  | 1.779  |          |          |          |          |          |          |          |          |          |          |          |          |          |          |          |
| F Statistic (df = 2; 1093) | 53.280*** | 58.741*** | 63.407*** | 74.164*** | 91.601*** | 169.580*** |          |          |          |          |          |          |          |          |          |          |          |          |          |          |

Note: *p < 0.1; **p < 0.05; ***p < 0.01.

3.2.1. Panel regressions

Table 2 presents the estimation results of four different specifications. Model (1) presents the fixed-effects panel regression results with the market (ASX200) and the price of gold denominated in US$. While both coefficients are highly significant, the market beta is slightly greater than the gold exposure which may be surprising given the nature of the companies.

The estimation results of model (2) allowing for different exposures during the COVID period show that the non-crisis exposures are lower compared with the basic model and that the exposures increase during the COVID period. The increase is larger for gold than for the market. The significantly increased exposure to both the market and gold is consistent with contagion from the market and from gold.

Model (3) accounts for the different types of firms (explorers, developers and producers) but not for the COVID period. The results show that the market exposure is monotonically increasing from producers to explorers with explorers displaying the greatest market exposure. In contrast, the gold exposure monotonically increases from explorers to producers with producers displaying the greatest
Table 6
Estimation results for portfolio of explorers, developers and producers and exchange rate changes.

| Dependent variable: | P1  | P2  | P3  |
|---------------------|-----|-----|-----|
| Market              | 0.390*** | 0.617*** | 0.455*** |
|                     | (0.038) | (0.057) | (0.051) |
| goldUS              | 0.512*** | 0.918*** | 1.470*** |
|                     | (0.060) | (0.090) | (0.080) |
| rfx                 | −0.342*** | −0.628*** | −1.007*** |
|                     | (0.048) | (0.072) | (0.064) |
| Constant            | −0.005 | −0.016 | 0.036 |
|                     | (0.039) | (0.059) | (0.053) |
| Observations        | 1,096 | 1,096 | 1,096 |
| $R^2$               | 0.129 | 0.156 | 0.269 |
| Adjusted $R^2$      | 0.127 | 0.154 | 0.267 |
| Residual Std. Error (df = 1092) | 1.305 | 1.956 | 1.742 |
| F Statistic (df = 3; 1092) | 54.078*** | 67.262*** | 134.162*** |

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$.

gold exposure. Interestingly, while the market exposure differences are statistically different, the gold exposure differences are not statistically significant.

Finally, model (4) presents the results for the full model nesting models (1) - (3). The interaction terms of the market returns and gold returns with the COVID crisis dummy and the explorer, developer and producer dummies (last six rows of estimates presented in Table) show an increased market exposure and a decreased gold exposure consistent with the decoupling of gold companies from the gold price during the COVID crisis period. The statistical insignificance of these estimates is also reflected in the low $R^2$ squares indicating that the returns are dominated by idiosyncratic risk. The significant coefficient of the gold returns with the COVID dummy are due to the falling gold price denominated in US dollar.

The results for the gold price denominated in A$ exhibit no such significance for the coefficient due to the rising price of gold denominated in A$. The estimation results for gold denominated in A$ are displayed in Table 3.

3.2.2. Correlation matrices

The correlation estimates for the pre-COVID and COVID period presented in Table 4 confirm these results, i.e. the correlation with the market increases significantly in the crisis period for all three types of gold companies and the correlation also increases significantly among the gold companies. The estimates further demonstrate that the increase in correlations of the gold companies share price returns is, on average, stronger with the market than with the gold price. This finding is consistent with the graphs that show a stronger co-movement of gold mining share prices with the market than with the price of gold. Table 4 includes the difference between the crisis and pre-crisis correlations and displays evidence for contagion if contagion is defined as an increase in the correlation in a crisis period relative to a pre-crisis period (e.g. see Baig and Goldfajn (1999) and Forbes and Rigobon (2002)). Specifically, the estimates indicate contagion (i) between the gold firms, (ii) between the gold firms and the market and (iii) between the gold firms and the price of gold in US$. To assess the statistical significance of the correlation matrices we employed several statistical tests (Steiger and Jennrich tests) that all reject the hypothesis that the correlation matrices are equal. To further test the robustness of this rather strong result we also tested restricted correlation matrices, e.g. a matrix that only contained the mining companies or only contained the ASX200 and gold in US$. The significant differences between the in-crisis and pre-crisis periods remained for all sub-matrices.

3.2.3. Portfolios

Table 5 presents the estimation results for equally-weighted portfolios of explorers (P1), developers (P2) and producers (P3) regressed on the market, the gold price in US$ and alternatively the gold price in A$. Table 6 presents the results using the A$/US$ exchange rate as a third regressor variable in addition to the market and the price of gold in US$.

The results confirm the results reported in the previous sections: the market and gold exposures are weakest for explorers and strongest for producers and increase monotonically for the specification with the gold price denominated in A$.

The regression results that include the A$/US$ exchange rate further show that both gold price exposures and exchange rate exposures increase monotonically from explorers to producers. The estimates imply that a depreciation of the A$ increases the value of the portfolio whereby an appreciation of the A$ decreases the value. This result is plausible because a weaker A$ implies higher gold prices in A$.
3.2.4. Gold firms’ market and gold exposures

The analysis in the previous section reports aggregate effects for each type of firm but not individual effects for each firm. In this section we focus on the exposure estimates of each firm and the role of systematic risk across firms.

Fig. 6. Histograms Market and Gold betas for Explorers, Developers and Producers.
Table 7  
Names of firms in sample.  

| # | Name                  | # | Name                        | # | Name                   |
|---|-----------------------|---|-----------------------------|---|------------------------|
| 1 | AFRICAN.GOLD          | 81| EVOLUTION.MINING            | 161| ORA.GOLD               |
| 2 | AIC.MINES             | 82| FIRST.AU                    | 162| ORA.BANDA.MININ        |
| 3 | ARUMA.RESOURCES       | 83| FOCUS.MINERALS              | 163| OCEANAGOLD.CDL         |
| 4 | ANGLO.AUST.RESO       | 84| GALLIEO.MINING              | 164| OKAPI.RESOURCES        |
| 5 | ARIDEN                | 85| GREAT.BOULDER.R             | 165| OKLO.RESOURCES         |
| 6 | AURA.ENERGY,SUS       | 86| GBM.RESOURCES               | 166| ORMINEX                |
| 7 | AUSTRAL.GOLD          | 87| GENESIS.RESOURCE            | 167| ORECORP                |
| 8 | ANGLOGOLD.ASHAN       | 88| GLADIATOR.RESOU             | 168| PREDICTIVE.DISC        |
| 9 | ALLIANCE.RESOUR       | 89| GENESIS.MINERAL             | 169| PANTORO                |
|10 | ACTIVEX               | 90| GATEWAY.MINING              | 170| PERSEUS.MINING         |
|11 | AUING.MINING,S        | 91| GOLD.MOUNTAIN               | 171| PRODIGY.GOLD.NL        |
|12 | ALKANE.RESOURCE       | 92| GOLDEN.RIM.RESO             | 172| PATERSON.RESOUR        |
|13 | ALCHEMY.RESOURCE      | 93| GREAT.NORTHERN.            | 173| PEAK.MINERALS          |
|14 | ARROW.MINERALS        | 94| GOLD.ROAD.RESOU             | 174| RED5                   |
|15 | ALTO.METALS           | 95| GEOPACIFIC.RESO             | 175| RESOURCES...ENE        |
|16 | AUSMEX.MINING,G       | 96| GREENVALE.MININ             | 176| RIVERSGOLD             |
|17 | AURELIA.METALS        | 97| GOLDEN.STATE.MI             | 177| RIEDEL RESOURCE        |
|18 | AMANI.GOLD            | 98| GREAT.SOUTHERN.             | 178| RIMFIRE.PACIFIC        |
|19 | APOLLO.CONTROLLED     | 99| GREAT.WESTERN.E             | 179| RESOLUTION.MINE        |
|20 | ALCANTARA.MINERALA    |100| GWR.GROUP                   | 180| RAMELUS.RESOUR         |
|21 | ALICE.QUEEN           |101| HAWTHORN.RESOUR             | 181| RAND.MINING            |
|22 | ARGENT.MINERALS       |102| HIGH.GRADE.META             | 182| RENEGADE.EXPLOR        |
|23 | ARDEA.RESOURCES       |103| HAMMER,METALS               | 183| REGIS.RESOURCES        |
|24 | ASTRO.RESOURCES       |104| HORIZON.GOLD                | 184| RESOLVE.MINING         |
|25 | ARTEMIS.RESOURCES     |105| HORIZON.MINERAL             | 185| RTG.MINING.CDI         |
|26 | AUSGOLD               |106| HAWKSTONE.MININ             | 186| ROX RESOURCES          |
|27 | AUSTAR.GOLD           |107| INDIANA.RESOURCE            | 187| REX MINERALS           |
|28 | AUTECO.MINERALS       |108| JADAR.RESOURCES             | 188| S2.RESOURCES           |
|29 | ANOVA.METALS          |109| KAIROS.MINERALS            | 189| SOUTHERN.GOLD          |
|30 | AUSTRALIA.UNITED      |110| KAISER.REEF                 | 190| ST.BARBARA             |
|31 | AZURE.MINERALS        |111| KINGSGATE,CONSO            | 191| SABRE.RESOURCES        |
|32 | ANTIPA.MINERALS       |112| KULA.GOLD                   | 192| SCORPION.MINERA        |
|33 | BATTERY.MINERALA      |113| KALWORTH,GOLD.M             | 193| STRATEGIC.ENERGY       |
|34 | BBX.MINERALS          |114| KIN.MINING                  | 194| SIHAYO.GOLD            |
|35 | BLACK.CAT.SYNDI       |115| KIRKLAND.LAKE.G             | 195| SKY.METALS             |
|36 | BEACON.MINERALS       |116| KAILIR.RESOURCES            | 196| SILVER.LAKE.ES         |
|37 | BARDOC.GOLD           |117| KINGSROSE.MININ             | 197| SULTAN.RESOURCE        |
|38 | BLACK.DRAGON.GO       |118| KINGSTON.RESOURCE           | 198| SOON.MINING.SUS        |
|39 | BELLEVUE.GOLD         |119| KINGWEST.RESOUR             | 199| SUPERIOR.RESOUR        |
|40 | BLAZE.INTERNATIONAL   |120| KALAMAZOO.RESOU             | 200| SATURN.METALS          |
|41 | BULLETIN.RESOUR       |121| LOS.CERROS                  | 201| SOUTHERN.HMSPHR        |
|42 | BREAKER.RESOUR        |122| LEGACY.IRON.ORIE            | 202| TANAMI.GOLD            |
|43 | BIG.RIVER.GOLD        |123| LEPROY.EXPLORAT              | 203| TARUGA.MINERALS        |
|44 | BASSARI.RESOURC       |124| LION.ONE.METALS             | 204| TRIBUTE.RESOURC        |
|45 | CANNINDAH.RESOU       |125| LANEWAY.RESOUR              | 205| THETA.GOLD.MINE        |
|46 | CALIDUS.RESOURC       |126| LODESTAR.MINERA             | 206| TIETTO.MINERALS        |
|47 | CASTLE.MINERALS       |127| MAGMATIC.RESOUR             | 207| TREK.MINERALS          |
|48 | CRATER.GOLD.MIN       |128| MANDRAKE.RESOUR             | 208| TEMPSU.RESOURCE        |
|49 | CHALICE.MINING        |129| MATSA.RESOURCES             | 209| TERRAIN.MINERAL        |
|50 | CHESSER.RESOURC       |130| MAGNETIC.RESOUR             | 210| TORIAN.RESOURCE        |
|51 | CLASSIC.MINERAL       |131| METAL.BANK                  | 211| TRUSSCOTT.MINING       |
|52 | CASSIUS.MINING        |132| METALICITY                  | 212| TROY.RESOURCES         |
|53 | CAPRICORN.METAL       |133| MIDDLE.ISLAND.R             | 213| TWENTY.SEVEN           |
|54 | CARNABY.RESOURC       |134| METEORIC.RESOUR             | 214| TESORO.RESOURC         |
|55 | CAPRICE.RESOURC       |135| MARMOTA                     | 215| TITAN.MINERALS         |
|56 | CITIGOLD              |136| MUSGRAVE.MINERA             | 216| TYRANNA.RESOURCE       |
|57 | CULLEN.RESOURCE       |137| MANHATTAN                   | 217| VANGO.MINING           |
|58 | CERVANTES.SUSP.       |138| MAKO.GOLD                   | 218| VECTOR.RESOURCE        |
|59 | CARAWINE.RESOURCE     |139| METALS.AUSTRALI             | 219| VENUS.METALS           |
|60 | CAUDRON.ENERGY        |140| MEDUSA.MINING               | 220| WEST.AFRICAN.RE        |
|61 | CYGNUS.GOLD           |141| MOHO.RESOURCES              | 221| WESTGOLD.RESOURCES     |
|62 | CATALYST.METALS       |142| MONT.ROYAL.RESO             | 222| WOOMERA.MINING         |
|63 | CZR.RESOURCES         |143| MANAS.RESOURCES             | 223| WHITE.ROCK.MINE        |  

(continued on next page)

Fig. 6 shows the distribution of market and gold betas for all firms in our sample, split by explorers, developers and producers. The average market exposures are largest for developers (0.42), followed by explorers (0.38) and miners (0.28). The gold betas of the firms reflect their different business activity. That is, the gold producers have higher gold betas (0.64), reflecting their cashflow.
exposure to the gold price, whereas both developers (0.31) and explorers (0.22) have lower gold betas, consistent with having no direct exposure to cashflow from gold despite their indirect exposure to gold price changes impacting the value of their in-ground, non-producing gold assets. Importantly, the average betas across individual regressions are almost identical to the estimates based on the fixed-effects and pooled regressions indicating the robustness of the main results. Consistent with the risk of the firms, the histograms also show the greatest dispersion of exposures for explorers and the smallest dispersion of exposures for producers (miners).

Given the low market exposure in “normal” times or on average and the low (well below one) gold exposure for the majority of firms we expect a small role of systematic risk measured by the market and gold price changes and thus high idiosyncratic risk of firms particularly for explorers and less so for developers and miners. Indeed, systematic risk plays a minor role for most firms and all firms are dominated by idiosyncratic risk. Even the relatively large gold miners only show an average $R^2$ of about 10% (for gold in A$) and thus an average idiosyncratic risk of 90%. The dominance of idiosyncratic risk in normal times does also apply for the COVID-19 crisis period despite a strong increase in the importance of the systematic risk factors. The increased $R^2$ to values between 10% and 25% is consistent with the contagious impact of the market as shown above.

4. Summary and conclusions

This paper is motivated by the COVID-19 induced stock market crash in March 2020 and the role of gold as a safe haven asset. Since gold shares, unlike gold bullion, have an equity component, they are not only linked to gold but also to the market. This link offers interesting insights into investor behaviour as a decoupling from the price of gold can be explained with an increasing importance of investor sentiment or uncertainty and be distinguished from fundamentals. Such a distinction is difficult when sentiment and fundamentals decline jointly. However, this is not the case for gold shares during a safe haven event when fundamentals remain constant or even improve and the market falls. While gold producers may be directly affected by potential closures of mines due to the pandemic such effects are less direct and severe for explorers and developers. Importantly, Jowitt (2020) notes that COVID-related mine disruptions at gold operations globally were minor.

Since gold shares have different risk characteristics based on the type of gold firm, i.e. gold explorers are most risky, gold developer are risky and gold miners are least risky, we can also analyse whether investors account for the different risks both in normal times and in crisis times.

Our analysis shows that gold firms decoupled from the price of gold during the COVID-19 period because the downward market force was stronger than the gold force consistent with financial contagion. The fact that all types of gold firms fell jointly and by a similar magnitude supports the contagion hypothesis.

The dominant role of the market resulting in a very similar performance of all three types of gold firms suggests that investors treated all firms similarly and did not distinguish between gold firms and other, non-gold firms, and not among gold firms, e.g. between high-risk gold explorers and low-risk gold miners. This finding is consistent with financial contagion and the temporary irrelevance of firm fundamentals. It seems that when investor sentiment or uncertainty are extreme, investors treat all firms the same leading to joint, contagious, falls that affect all stocks in the same way.

Since the price of gold and thus the core revenue source of gold firms increased during the crisis, the lower stock valuations suggest an undervaluation of gold firms, particularly gold producers with the most direct link to gold, and a reaction to the COVID-19 shock that is not related to the fundamentals or core revenue stream-gold. This is why gold shares are particularly interesting and why they offer a perspective that is rarely offered by other stocks as it is hard to disentangle changes in fundamentals from changes

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7 The detailed results can be obtained from the authors.
in market sentiment. In this case, whilst the sentiment has changed, the fundamentals with respect to gold have not changed. If anything, the fundamentals have improved for gold producers given the role of gold as a safe haven in response to extreme shocks.

This study shows that categorising gold companies into explorers, developers and producers reveals different market and gold exposures both in normal times and crisis times. Gold shares were pulled down by the market during the COVID outbreak despite their fundamental link to gold bullion highlighting the difference of gold equity and gold bullion.

Appendix

See Table 7.

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