Returns in US copper companies the face of the volatility and stringency of COVID-19

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Abstract

Copper plays an important role in the production of technology and portfolios, yet it still faces the consequences of COVID-19. The financial literature that includes copper does so together with other commodities, resulting in reduced coverage of the determinants of this metal, leaving questions. We will use linear and VAR-X models to relate the financial market volatility (VIX) and the management of the spread of COVID-19 (*stringency*) to the returns of copper companies in the United States. We found evidence that the VIX and *stringency* have a negative effect on the returns of these companies, with Chile's *stringency* being the most negative. This evidence suggests that investors seem to prioritize their actions on copper production (Chile), and more on volatility, if present. This may help to better understand investors' actions in the face of such scenarios.

JEL codes: G11, G12, G15, G18.
Keywords: Mining; Copper; COVID-19; Lockdown Stringency; Uncertainty.

I Introduction

Studies related to copper have become increasingly relevant due to its role as an input for new technologies (Nguyen et al., 2021; Schipper et al., 2018), as well as in the evolution and stability of the securities market (Daskalaki and Skiadopoulos, 2011), especially in those companies focused on this mineral. On the other hand, we must consider that in 30 years' time the demand for copper is expected to be 3 to 4 times the current level (Deetman et al., 2018; Elshkaki et al., 2016), although it was affected by COVID-19, in China it decreased due to the reduction of manufacturing production (Shen et al., 2020), in the United States due to the contraction of the construction sector (Pollok, 2020) and in Chile due to the drop in mining production (Fiscor, 2021; Specht, 2021).

Several studies show that pandemics are an increasingly frequent and long-lasting event (Castle et al., 2022), due to global warming and overpopulation (Madhav et al., 2018). Marani et al. (2021) studies find a 38% probability that an event similar to COVID-19 will be repeated in the coming decades, a number that may increase if some conditions are met. On the other hand, Zhang and Wang (2021) explore the impact of COVID-19 on the volatility of some commodities, including copper, using the ARMA-GARCH model. Farid et al. (2021) show evidence of dramatic changes in volatility among stocks and major commodities in the U.S. economy before and during the COVID-19 outbreak. These studies do not focus on copper, and therefore, do not control for several relevant factors, such as the level of inventory and the level of speculation in its market.

For our research, we expect higher financial market volatility and more restrictive measures on COVID-19 developments to have a negative effect on the returns of U.S. copper-focused companies. Using linear time series estimations and VAR-X models, controlling for various determinants of this metal (Mendiola et al., 2019), we found evidence suggesting that, in the face of increased volatility and restrictions, investors appear to prioritize volatility, negatively affecting the returns of these companies (Chung and Chuwonganant, 2018). In addition, we found that the restrictions in Chile had a greater impact on the returns of these companies than those applied in the United States, probably because the measures were less rigorous than those in Chile, although it could be that the investors cover the extraction and then the commercialization of copper.

II Empirical strategy

II.1 Data

Stock prices and the Baltic Dry Index (BDI) are obtained from Refinitiv Eikon [1]. The $S\&P500$, the Goldman Sachs Commodity Index (GSCI), the Chicago Board Options Exchange Market Volatility Index (VIX) and Chile's exchange rate are obtained from a public source [2]. Copper prices are extracted from the London Metal Exchange (P_{Cu}) and inventory data (*Stock*) from the Comisión Chilena del Cobre (COCHILCO) of the Ministry of Mining of the Government of Chile [3]. The *Stringency* index comes from Oxford COVID-19 Government Response Tracker[4] (OxCGRT), represented by S_{US} for the United States and S_{CL} for Chile. This index shows the strictness with which control measures have been applied

[1] https://www.refinitiv.com
[2] Yahoo Finance
[3] https://www.cochilco.cl
[4] https://ourworldindata.org/metrics-explained-covid19-stringency-index

to COVID-19, ranging from a minimum of 0 to a maximum of 100, so that in Chile there were stricter measures than in the United States, as shown in the table 1.

We also use the percentage continuous returns [5] of five copper companies for the United States (Mendiola et al., 2019). Additionally, we include the continuous return of copper price (R_{Cu}), financial market (RM) based on the $S\&P500$, commodities market (RG) based on the GSCI, Chile's exchange rate ($Ex_{\$/\$US}$) and the percentage change in daily COVID-19 fatalities (OxCGRT) for both the United States (DD_{US}) and Chile (DD_{CL}). The statistical description of the variables is shown in the Table 1, for the period from May 28, 2020, to May 18, 2021, when the restriction measures began and had more movement.

Table 1: Summary statistics of the sample variables.

Variables	Mean	SD	Min	Max
Continued returns of copper companies				
[1] Alcoa	0.608	4.220	-15.525	11.430
[2] BHP	0.227	2.010	-7.499	6.996
[3] Freeport	0.657	3.450	-14.619	10.318
[4] Rio	0.264	1.930	-5.857	4.762
[5] Southern	0.330	2.357	-8.957	6.710
Market controls				
R_{Cu}	0.299	1.341	-5.314	3.476
BDI	0.771	4.074	-8.836	20.337
RG	0.248	1.249	-4.035	3.284
RM	0.139	1.175	-6.075	2.987
Stocks	-0.092	2.675	-7.237	16.943
$Ex_{\$/\$US}$	-0.052	0.897	-2.085	2.466
Exogenous controls				
$\ln(VIX)$	3.185	0.191	2.788	3.708
S_{US}	47.797	7.821	36.110	65.740
S_{CL}	80.480	2.936	73.610	87.500
DD_{US}	1.287	1.199	0.087	6.836
DD_{CL}	1.566	3.814	0.043	44.695

Note: The variables described are the continuous percentage returns of the companies [1] to [5], the copper price R_{Cu}, the Baltic Dry Index (BDI), the financial market (RM), the commodities market (RG), the inventory (*Stock*), the exchange rate of the Chilean peso to the US dollar $Ex_{\$/\$US}$. In addition, the natural logarithm of the VIX and the *Stringency* for the United States S_{US} and for Chile S_{CL} are included, as well as the percentage change in daily COVID-19 deaths in the United States DD_{US} and in Chile DD_{CL}. Source: Own production. 222 observations.

II.2 Models

First, we will use the model described in the equation (1) to obtain the elasticities between the return of copper mining companies (see Table 3, Annex) in the face of changes in their spot price, which will allow us to have a reference to analyze the effects of changes in exogenous variables on the returns of these companies. The equation model (1) sets the continuous return of the five companies of interest by, $R_{i,t}$ with $i = 1, 2, ..., 5$. The controls correspond to *Stringency* for the United States and Chile, natural logarithm of the VIX and interactions between *Stringency* and $ln(VIX)$, in addition the percentage change in daily COVID-19 fatalities for the United States (DD_{US}) and Chile (DD_{CL}) were included. Vector $\mathbf{X}$ represents market controls (see Table (1)).

[5] $r = [\ln(Price_t) - \ln(Price_{t-1})] \times 100\%$.

$$R_{i,t} = \alpha + \beta_1 \cdot S_{US,t} + \beta_2 \cdot S_{CL,t} + \beta_3 \cdot \ln(VIX) + \beta_4 \cdot \ln(VIX) \times S_{US,t} + \beta_5 \cdot \ln(VIX) \times S_{CL} + \mathbf{B} \cdot \mathbf{X}_t + \varepsilon_t \quad (1)$$

Second, COVID-19 affected the stock prices of the five copper companies described (Mendiola et al., 2019), so, we will also estimate a $VAR - X$ model. This methodology allows us to analyze shocks in exogenous variables. VIX and *Stringency*, are exogenous to copper and copper company stock prices, which is why this method fits our research. Therefore, the second model to be estimated will be the one described in the equation (2), where the choice of the delay is based on different information criteria (see Annex Table 4).

To obtain an economic interpretation of the residuals, $\mathbf{e}_t$, from the reduced form of the $VAR - X$ presented in the equation (2), we will employ the Cholesky decomposition to identify the structural shocks (Ocampo and Rodríguez, 2012), which makes it necessary to order the variables of the endogenous vector. Following the approach described by Bakas and Triantafyllou (2018); Bekaert et al. (2013), we select the order of the endogenous vector variables as $\mathbf{Y}_t = [BDI_t \;\; RM_t \;\; RG_t \;\; R_{Cu} \;\; R_{[i],t}]'$, with $\mathbf{Y}_{t-1}$ being the first delay. In addition, $\mathbf{H}_t$ represents the vector of exogenous variables of the form $\mathbf{H}_t = [VIX_t \;\; S_{US,t} \;\; S_{CL,t}]'$.

$$\mathbf{Y}_t = \Theta_0 + \Theta_1 \cdot \mathbf{Y}_{t-1} + \Phi \cdot \mathbf{H}_t + \mathbf{e}_t \qquad \forall \; \mathbf{e}_t \;\sim\; N(0, \Omega_t) \quad (2)$$

We will analyze the impact of a shock on the exogenous vector $\mathbf{H}_t$, on the endogenous vector $\mathbf{Y}_t$, of the equation 2, using the impulse response of the $VAR - X$. To calculate the impulse response, we will use dynamic multiplicative functions (DMFs), which will allow us to capture the effects of a shock to the exogenous variables by one unit (Lütkepohl, 2005), for this reason we modify the variables VIX to a standard normal scale and *Stringency* to a binary variable that takes the value 1 when the tightening measures are more severe.

III Results

From the model equation (1), we examined the relationship between the returns of copper companies and the price of copper and found a positive inelastic relationship, results that are consistent with those obtained by Mendiola et al. (2019). We can see from the table 2 that a 1% increase in copper returns causes a 0.47% increase in the returns of *Freeport*, which is significant and the most elastic observed among the five companies. The most inelastic was BHP with 0.26%, while the least significant is *Alcoa* with 0.27%.

Regarding the tightening of quarantines, the effect is not so clear. On the one hand, the marginal change in *stringency*, for an average of $\ln(VIX)$ equal to 3,185 (see Table 1), is not significant, neither that of the United States nor that of Chile (see *Marginal changes*, Table 2). However, when we analyze the effects separately, in all cases, the impact of Chile's *stringency* is more negative than that of the United States, with BHP's being the most significant. This could mean that, in the absence of uncertainty in the financial market, investors' concerns would be more about copper production than about the decisions made by the selected companies. Looking at the interaction with the volatility index (VIX), the marginal change is not significant, but the individual effect is negative, possibly because in the face of market uncertainty and COVID-19 developments, investors face volatility and then a pandemic.

Regarding the second model described in equation (2), on the $VAR - X$, first we established that the stability of the model for the endogenous variable is the first delay, which was established based on the information criteria (see Table 4, Annex). All the endogenous variables of the model are continuous returns, which were found to be stationary for estimation purposes. The different base estimates for the calculation of the impulse response to the shocks of the exogenous variables are detailed in the Annex.

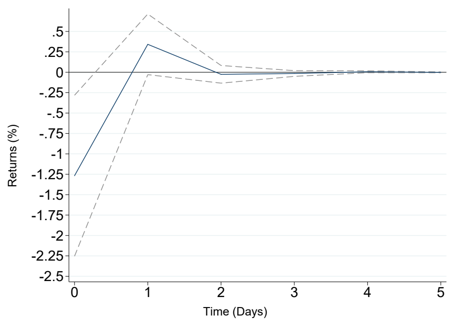
Our estimates show that a shock in the VIX of one standard deviation, equivalent to 0.2 (see Table 1), caused a drop in returns for companies of slightly more than 1%, lasting two days, as illustrated by the impulse-response graphs in Figure 1. In the case of a shock to the U.S. *stringency* variable, we found a drop in all companies, except for *Alcoa*, which hovers around 0.5%, as seen in the impulse-response plots in Figure 2. While in the case of a relaxation in Chile's *stringency* it also has a negative effect (see Figure 3), although 0.5% higher than in the case of the United States, which is consistent with the findings of the estimation of the equation (1).

Table 2: Equation estimation (1) for copper companies in US/COVID-19.

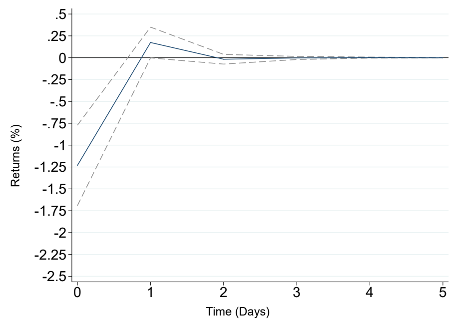
VARIABLES	[1] Alcoa	[2] BHP	[3] Freeport	[4] Rio	[5] Southern
R_{Cu}	0.2728	0.2602***	0.4714***	0.3121***	0.4071***
	(1.4806)	(2.7149)	(3.2866)	(3.2337)	(3.3824)
BDI	0.0392	0.0215	0.0593	0.0089	0.0330
	(0.6395)	(0.6969)	(1.0476)	(0.2846)	(0.9301)
RM	1.3027***	0.7511***	1.4229***	0.6162***	0.9835***
	(5.2730)	(7.8758)	(7.3529)	(6.1350)	(7.8122)
RG	0.6721***	0.3896***	0.5358***	0.2877***	0.1656
	(2.8683)	(4.1384)	(3.0626)	(2.8943)	(1.3922)
$Stock$	-0.1582**	-0.1094***	-0.1427**	-0.1001***	-0.1330***
	(-1.9815)	(-2.8625)	(-2.5404)	(-3.0264)	(-3.4551)
$Ex_{\$/\$US}$	0.5524*	0.1517	0.1232	0.1397	0.1337
	(1.6874)	(1.2145)	(0.5785)	(1.0245)	(0.9130)
$\ln(VIX)$	-88.9338*	-46.6297**	-45.9872	-46.1315**	-39.8800
	(-1.8007)	(-2.3503)	(-1.2867)	(-2.2876)	(-1.5729)
S_{CL}	-3.0563	-1.5004*	-1.4466	-1.5925*	-1.3759
	(-1.4636)	(-1.7847)	(-0.9334)	(-1.8388)	(-1.2729)
S_{US}	-0.5690	-0.5628**	-0.5981	-0.3437	-0.3612
	(-0.8133)	(-2.0958)	(-1.1374)	(-1.1780)	(-1.0458)
$\ln(VIX) \times S_{US}$	0.1700	0.1697**	0.1878	0.1029	0.1131
	(0.7798)	(2.0469)	(1.1502)	(1.1378)	(1.0560)
$\ln(VIX) \times S_{CL}$	0.9992	0.4690*	0.4663	0.5024*	0.4333
	(1.4979)	(1.7809)	(0.9577)	(1.8445)	(1.2750)
DD_{US}	-0.2728	0.0073	-0.0656	-0.0690	-0.0136
	(-1.2124)	(0.0735)	(-0.3724)	(-0.7072)	(-0.0939)
DD_{CL}	0.1016	0.0442***	0.0601**	0.0571***	-0.0015
	(1.5921)	(2.6394)	(2.1035)	(3.7465)	(-0.0399)
Constant	274.7284*	149.9278**	143.4533	147.0627**	126.7309
	(1.7747)	(2.3665)	(1.2634)	(2.2906)	(1.5739)
Marginal changes with interaction					
$^{(a)}\ln(VIX)$	-0.3931	-0.7736	0.5167	-0.7082	0.3977
	[0.7818]	[0.1700]	[0.6135]	[0.1909]	[0.6193]
$^{(a)}S_{US}$	-0.0276	-0.0223	0.0000	-0.0160	-0.0010
	[0.4141]	[0.1051]	[0.9998]	[0.2780]	[0.9459]
$^{(a)}S_{CL}$	0.1262	-0.0066	0.0386	0.0076	0.0042
	[0.1756]	[0.8539]	[0.5726]	[08461]	[09275]
Observations	222	222	222	222	222
R-squared	0.2949	0.5008	0.4397	0.3936	0.3945

Note: The dependent variables correspond to the stock price returns of the five U.S. copper companies. (a) is the marginal change for variables with interaction (d/dX), subjected to an F-test for significance with p value in brackets. Source: Own production. t-statistic in parentheses. */**/*** significant to 10%/5%/1%, respectively.

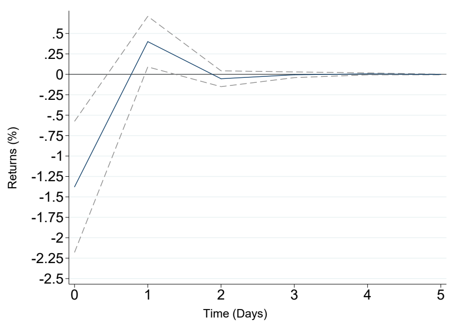
Figure 1: Impulse response of the VIX on returns of U.S. copper companies.



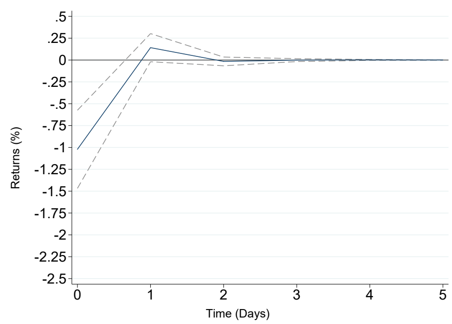
(a) Alcoa Inc.



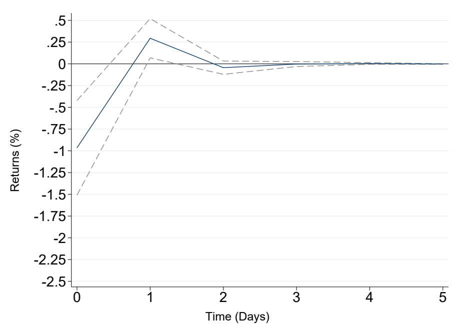
(b) BHP Billiton



(c) Freeport McMoRan

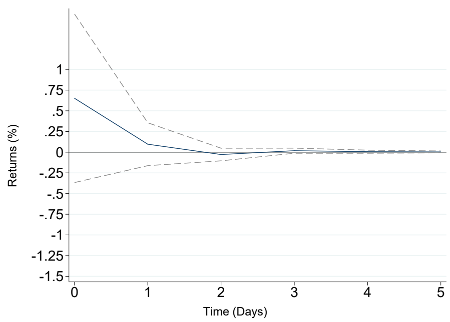


(d) Rio Tinto

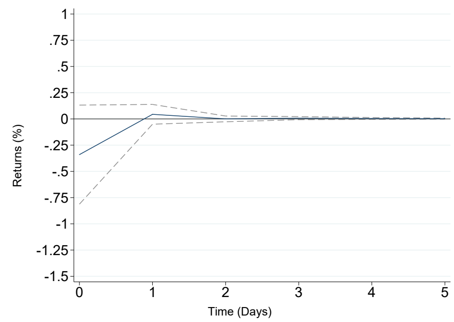


(e) Southern Copper

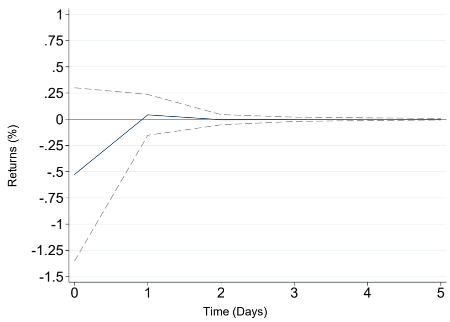
Figure 2: Impulso respuesta del *Stringency* US on returns of U.S. copper companies.



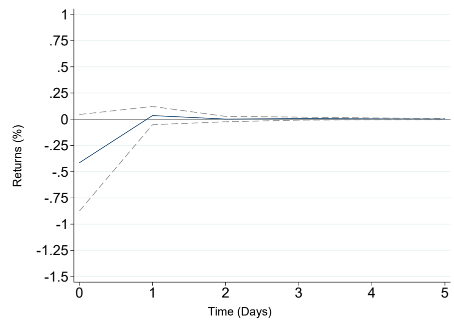
(a) Alcoa Inc.



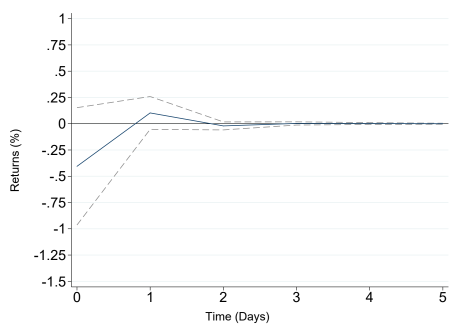
(b) BHP Billiton



(c) Freeport McMoRan

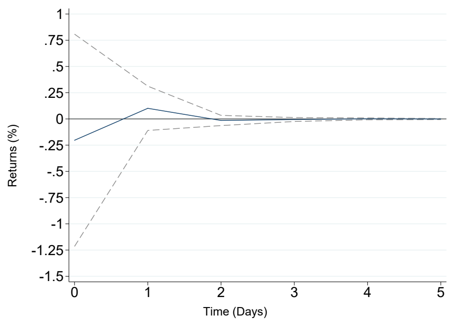


(d) Rio Tinto

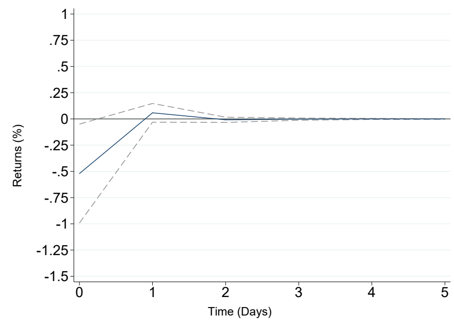


(e) Southern Copper

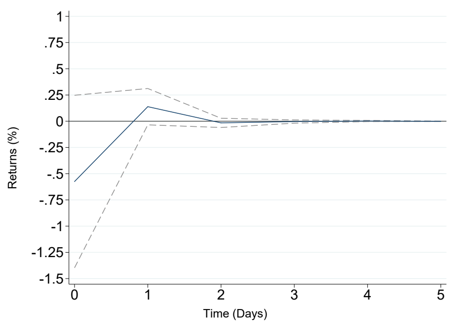
Figure 3: Impulso respuesta del *Stringency* Chile on returns of U.S. copper companies.



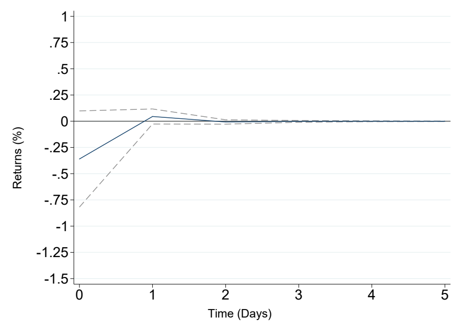
(a) Alcoa Inc.



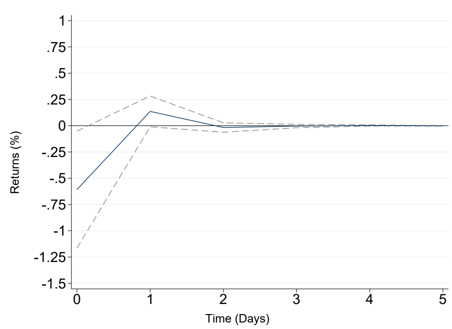
(b) BHP Billiton



(c) Freeport McMoRan



(d) Rio Tinto



(e) Southern Copper

Note: Impulse Response (IR) of the market volatility (VIX), on the returns of the 5 copper companies, for the $VAR - X$ of the equation (2). The vertical axis represents returns in percentage points and the horizontal axis represents the period in days. The solid line represents the IR on each copper company and the dashed lines represent the 95% confidence interval. The scale had to be modified between figures due to the impact diversity.

IV Conclusions

We found evidence of the negative relationship between the returns of copper companies in the United States and the volatility of the financial market, exposed by the VIX index and the harshness with which the sanitary control measures for COVID-19 have been applied, *stringency*. Our evidence suggests that, on the one hand, when investors face financial market volatility and mobility restrictions, they seem to attend more urgently to market volatility. On the other hand, with reduced financial market volatility, it appears that an increase in mobility restrictions has a more negative effect when applied in the countries where copper is mined, rather than in the countries where the copper-focused companies are located. And, although the *stringency* measures were harsher in Chile than in the United States, it is possible to assume that investors seem to react with more urgency to effects on copper production than on copper-focused companies.

The implementation of our VAR-X model to the data showed a negative impulse-response for the VIX and *stringency* shocks, with higher impact on BHP Billiton, and lower effect on Alcoa Inc. possibly because the latter is less dependent on copper (Galevsky et al., 2018). We find that an increase in financial market volatility has a negative impact on the returns of the selected companies, which seems to be related to an increase in risk premiums and illiquidity premiums (Chung and Chuwonganant, 2018).

These findings show us that financial decisions are not only a reaction to the conditions of this market, but thanks to this evidence it is possible to understand that there is a priority order for the execution of actions, and it seems that these actions first seek to stabilize and support the financial market and then respond to the problems of indirect sources. That said, it is important to understand which variables have the greatest impact on these companies, considering that pandemics (Castle et al., 2022), and natural disasters (Berlemann and Eurich, 2021), are becoming more frequent.

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V Annex

Table 3: List of selected companies

New York Stock Exchange	Headquartes	Market cap (MMUSD)	Earning (MMUSD)
Alcoa Inc. (Alcoa)	New York	6.42	9.32
BHP Billiton (BHP)	Melbourne	97.82	34.69
Freeport McMoRan (Freeport)	Phoenix	18.07	14.83
Rio Tinto (RIO)	London	71.52	33.78
Southern Copper (Southern)	Phoenix	27.43	5.38

Note: The following table presents the companies, selected for this research. Market capitalization is as of 13th March 2017. Revenue is as reported for the last Business Year. Sources: YahooFinance, 2017c Reuters (2017).

Table 4: Criterios de información para los rezagos óptimos

Lag	FPE	AIC	HQIC	SBIC
0	46.3732	15.1882	15.2645	15.3770
1	**29.2356***	**14.7268***	**14.9048***	**15.1672***
2	29.5664	14.7378	15.0174	15.4299
3	30.2232	14.7592	15.1405	15.7029
4	31.3051	14.7934	15.2765	15.9888

Nota: The table shows the results of the information criteria for the choice of the lags of the $VAR - X$ used in the model described in the equation (2). Source: Own production. */**/*** significant to 10%/5%/1%, respectively.

Table 5: VAR-X estimate for the company *Alcoa Inc.*

VARIABLES	BDI	RG	RM	*Stock*	[1] Alcoa
First lag endogenous controls					
BDI	0.631***	0.0168	0.0141	-0.00582	-0.0237
	(0.0523)	(0.0200)	(0.0187)	(0.0217)	(0.0691)
RG	0.0962	-0.101	-0.00614	0.0512	-0.524**
	(0.194)	(0.0741)	(0.0694)	(0.0806)	(0.257)
RM	-0.139	0.0817	-0.0978	0.145*	-0.136
	(0.212)	(0.0810)	(0.0758)	(0.0880)	(0.280)
R_{Cu}	0.0750	-0.131**	-0.102*	-0.165**	0.0763
	(0.164)	(0.0625)	(0.0585)	(0.0679)	(0.216)
[1]*Alcoa*	-0.0382	0.0344	-0.0155	0.0242	-0.0213
	(0.0575)	(0.0219)	(0.0205)	(0.0239)	(0.0760)
Exogenous controls					
z-VIX	-0.0673	-0.453***	-0.754***	-0.336*	-1.268**
	(0.454)	(0.173)	(0.162)	(0.188)	(0.599)
S_{US} [High = 1]	-0.546	-0.234	0.0357	-0.269	0.651
	(0.469)	(0.179)	(0.167)	(0.194)	(0.619)
S_{CL} [High = 1]	0.111	-0.143	-0.249	-0.120	-0.203
	(0.465)	(0.178)	(0.166)	(0.193)	(0.615)
Constant	0.427	0.578***	0.602***	0.587***	1.210**
	(0.419)	(0.160)	(0.150)	(0.174)	(0.554)
Observations	220	220	220	220	220

Note: The dependent variable is the vector of endogenous variables of the VAR-X model for the company corresponding to *Alcoa*. The controls correspond to the endogenous vector under the first delay and the vector of exogenous variables, as described in the equation (2). From these results, the impulse response is obtained for the company *Alcoa*. Source: Own production. Standard error in parentheses. */**/*** significant to 10%/5%/1%.

Table 6: VAR-X estimate for the company *BHP Billiton*.

VARIABLES	BDI	RG	RM	*Stock*	[2] BHP
First lag endogenous controls					
BDI	0.628***	0.0176	0.0143	-0.00510	-0.0208
	(0.0523)	(0.0201)	(0.0187)	(0.0217)	(0.0321)
RG	0.0261	-0.0913	0.00380	0.0622	-0.0787
	(0.198)	(0.0759)	(0.0707)	(0.0824)	(0.122)
RM	-0.282	0.102	-0.0781	0.168*	-0.117
	(0.226)	(0.0866)	(0.0807)	(0.0939)	(0.139)
R_{Cu}	0.0347	-0.132**	-0.0917	-0.162**	-0.0299
	(0.167)	(0.0641)	(0.0597)	(0.0696)	(0.103)
$[2]BHP$	0.118	0.0326	-0.0516	0.0119	-0.0317
	(0.140)	(0.0536)	(0.0499)	(0.0581)	(0.0859)
Exogenous controls					
z-VIX	-0.0458	-0.441**	-0.768***	-0.330*	-1.232***
	(0.454)	(0.174)	(0.162)	(0.189)	(0.280)
S_{US} [High = 1]	-0.560	-0.203	0.0167	-0.248	-0.340
	(0.467)	(0.179)	(0.167)	(0.194)	(0.287)
S_{CL} [High = 1]	0.134	-0.137	-0.258	-0.118	-0.521*
	(0.466)	(0.179)	(0.166)	(0.194)	(0.287)
Constant	0.412	0.569***	0.612***	0.582***	1.138***
	(0.420)	(0.161)	(0.150)	(0.175)	(0.258)
Observations	220	220	220	220	220

Note: The dependent variable is the vector of endogenous variables of the VAR-X model for the company corresponding to BHP. The controls correspond to the endogenous vector under the first delay and the vector of exogenous variables, as described in the equation (2). From these results, the impulse response is obtained for the company BHP. Source: Own production. Standard error in parentheses. */**/*** significant to 10%/5%/1%.

Table 7: VAR-X estimate for the company *Freeport McMoRan*.

VARIABLES	BDI	RG	RM	*Stock*	[3] Freeport
First lag endogenous controls					
BDI	0.632***	0.0184	0.0139	-0.00855	0.00303
	(0.0523)	(0.0201)	(0.0187)	(0.0212)	(0.0562)
RG	0.106	-0.0742	-0.00975	0.0105	0.0924
	(0.195)	(0.0747)	(0.0696)	(0.0788)	(0.209)
RM	-0.0917	0.140	-0.0998	0.0140	-0.394
	(0.229)	(0.0878)	(0.0819)	(0.0926)	(0.246)
R_{Cu}	0.0963	-0.119*	-0.0996*	-0.209***	-0.211
	(0.167)	(0.0641)	(0.0597)	(0.0676)	(0.179)
$[3]Freeport$	-0.0678	-0.00905	-0.0128	0.112***	-0.0506
	(0.0792)	(0.0304)	(0.0284)	(0.0321)	(0.0851)
Exogenous controls					
z-VIX	-0.0571	-0.446**	-0.753***	-0.358*	-1.377***
	(0.454)	(0.174)	(0.162)	(0.184)	(0.488)
S_{US} [High = 1]	-0.602	-0.211	0.0188	-0.206	-0.526
	(0.467)	(0.179)	(0.167)	(0.189)	(0.502)
S_{CL} [High = 1]	0.109	-0.144	-0.249	-0.117	-0.575
	(0.465)	(0.179)	(0.167)	(0.188)	(0.500)
Constant	0.446	0.577***	0.606***	0.559***	1.781***
	(0.419)	(0.161)	(0.150)	(0.170)	(0.451)
Observations	220	220	220	220	220

Note: The dependent variable is the vector of endogenous variables of the VAR-X model for the company corresponding to *Freeport*. The controls correspond to the endogenous vector under the first delay and the vector of exogenous variables, as described in the equation (2). From these results, the impulse response is obtained for the company *Freeport*. Source: Own production. Standard error in parentheses. */**/*** significant to 10%/5%/1%.

Table 8: VAR-X estimate for the company *Rio Tinto*.

VARIABLES	BDI	RG	RM	*Stock*	[4] RIO
First lag endogenous controls					
BDI	0.629***	0.0180	0.0137	-0.00530	-0.0170
	(0.0520)	(0.0200)	(0.0186)	(0.0216)	(0.0313)
RG	0.0192	-0.0847	-0.000823	0.0407	-0.0371
	(0.193)	(0.0744)	(0.0692)	(0.0801)	(0.116)
RM	-0.316	0.113	-0.0816	0.114	-0.109
	(0.216)	(0.0830)	(0.0772)	(0.0894)	(0.129)
R_{Cu}	0.00393	-0.130**	-0.0872	-0.190***	-0.0258
	(0.168)	(0.0647)	(0.0602)	(0.0697)	(0.101)
[4]*RIO*	0.193	0.0223	-0.0563	0.0961*	-0.0324
	(0.133)	(0.0513)	(0.0477)	(0.0553)	(0.0801)
Exogenous controls					
z-VIX	-0.0540	-0.446**	-0.761***	-0.324*	-1.021***
	(0.452)	(0.174)	(0.162)	(0.187)	(0.272)
S_US [High = 1]	-0.543	-0.204	0.0142	-0.234	-0.415
	(0.465)	(0.179)	(0.167)	(0.193)	(0.280)
S_CL [High = 1]	0.126	-0.142	-0.253	-0.113	-0.360
	(0.464)	(0.179)	(0.166)	(0.192)	(0.279)
Constant	0.403	0.571***	0.611***	0.571***	1.031***
	(0.418)	(0.161)	(0.150)	(0.173)	(0.251)
Observations	220	220	220	220	220

Note: The dependent variable is the vector of endogenous variables of the VAR-X model for the company corresponding to RIO. The controls correspond to the endogenous vector under the first delay and the vector of exogenous variables, as described in the equation (2). From these results, the impulse response is obtained for the company RIO. Source: Own production. Standard error in parentheses. */**/*** significant to 10%/5%/1%.

Table 9: VAR-X estimate for the company *Southern Copper*.

VARIABLES	BDI	RG	RM	*Stock*	[5] Southern
First lag endogenous controls					
BDI	0.630***	0.0180	0.0140	-0.00589	7.70e-05
	(0.0523)	(0.0200)	(0.0186)	(0.0213)	(0.0380)
RG	0.0822	-0.0816	-0.00557	0.0444	-0.153
	(0.191)	(0.0734)	(0.0681)	(0.0780)	(0.139)
RM	-0.126	0.110	-0.0542	0.0407	-0.0839
	(0.227)	(0.0871)	(0.0808)	(0.0925)	(0.165)
R_{Cu}	0.0909	-0.130**	-0.0803	-0.212***	-0.0695
	(0.169)	(0.0648)	(0.0600)	(0.0688)	(0.123)
[5] Southern	-0.0647	0.0178	-0.0644	0.137***	-0.141*
	(0.112)	(0.0428)	(0.0397)	(0.0455)	(0.0811)
Exogenous controls					
z-VIX	-0.0492	-0.454***	-0.733***	-0.381**	-0.965***
	(0.455)	(0.175)	(0.162)	(0.186)	(0.331)
S_{US} [High = 1]	-0.592	-0.203	0.00748	-0.215	-0.406
	(0.468)	(0.179)	(0.166)	(0.191)	(0.340)
S_{CL} [High = 1]	0.103	-0.141	-0.257	-0.102	-0.608*
	(0.466)	(0.179)	(0.166)	(0.190)	(0.338)
Constant	0.433	0.574***	0.605***	0.580***	1.243***
	(0.419)	(0.161)	(0.149)	(0.171)	(0.304)
Observations	220	220	220	220	220

Note: The dependent variable is the vector of endogenous variables of the VAR-X model for the company corresponding to *Southern*. The controls correspond to the endogenous vector under the first delay and the vector of exogenous variables, as described in the equation (2). From these results, the impulse response is obtained for the company *Southern*. Source: Own production. Standard error in parentheses. */**/*** significant to 10%/5%/1%.