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COVID-19, firm exposure, and firm value: A tale of two lockdowns

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ABSTRACT

We study how a public health crisis affects the corporate sector at different phases of outbreak. Using an event study approach, we find significant valuation effects in a sample of Chinese listed firms following two symbolic events in the outbreak of COVID-19: (1) the lockdown of Hubei province; and (2) the containment of the disease in China and its spread to overseas. Market responded negatively (positively) to the first (second) event. Regression analysis further reveals that, following the first event, firms with Hubei (foreign) exposures earned significantly lower (higher) returns. Foreign exposures, however, had significantly negative effects on returns following the second event. The valuation effects of Hubei and foreign exposures also vary across firm ownership and industries. Our results indicate that, in a globalized world, firms’ international status, internal networks and input-output linkages all play important roles in determining their exposures to the pandemic.

1. Introduction

First detected in Wuhan China, COVID-19 has rapidly spread to many parts of the world. The World Health Organization (WHO) on March 11 declared it a pandemic.1 How does a health crisis like this affect the corporate sector at different phases of outbreak in a globalized world? What are the determinants of a firm’s exposures to the crisis? How does firms' involvement in international trade and foreign direct investment (FDI) activities affect their values as the disease spread from domestic to overseas? Also, what are the roles of networks, including both the within-firm internal networks and the between-firm input-output (I-O) linkages, in determining firm exposures to the adverse health shock?

In this study, we aim to contribute by empirically examining the above important yet unexplored research questions. Tackling these research issues face two challenges. First, severe health crises do not occur often. While the recent outbreak of COVID-19 is certainly

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See the following webpage for details of the WHO’s declaration. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020.

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unfortunate, it provides researchers with a rare opportunity to investigate these questions. A second empirical challenge is that it would likely take time for the economic outcomes following a large-scale adverse health shock to fully realize; but during the long-time horizon many other factors can also change, which would then make it harder to distinguish the effect of a negative health shock from the effects of other concurrent changes. To overcome the second empirical challenge, we take advantage of the fact that stock market participants take into consideration future developments in the current pricing of a firm’s equity and employ an event study approach.

Specifically, we examine the firm valuation effects of two symbolic events in the outbreak of COVID-19: (1) the lockdown of Hubei province; and (2) the containment of the disease in China and its spread to overseas, using a sample of Chinese listed firms. We study both the market responses to the events and the determinants of the valuation effects. Overall, our results suggest that a public health crisis can have significant impacts on corporates, and the effects vary at different stages of outbreak. They also indicate that a firm’s international status, internal networks, and I-O linkages are important determinants of its exposures to the health shock.

The remainder of this paper is structured as follows. In Section 2, we describe the data and methodology. Section 3 reports our results, and Section 4 provides further discussions on our findings. Concluding remarks are offered in Section 5.

2. Data and empirical methodology

2.1. Data description

To carry out our analysis, we combine data from several sources. The first source is the China Stock Market & Accounting Research (CSMAR) database, which provides detailed information about firm-level stock returns and financial data. The second source is the Chinese custom data which contains the universe of Chinese imports and exports transactions at the HS 8-digit product level. Since there is no consistent coding system of firm identity between the two databases, we merge them by matching company names. In particular, we use a name (Chinese company names) recognition program implementing the fuzzy matching method. If the names are close but not identical, we manually check the matches and make necessary adjustments for abbreviations and typos.

In addition, we also obtain firm-level foreign direct investment and subsidiary information from Financial Time’s Di Markets database and CSMAR’s Related Party Transaction database. Finally, we employ the China’ 2012 province-sector-level I-O table in the construction of our I-O based firm exposure measures. After removing financial firms and special-treated firms, our sample contains 2363 observations. Details of variable definitions and data sources are shown in Online Appendix Table A1, and summary statistics are reported in Online Appendix Table A2.

2.2. Empirical methodology

To study the valuation effects of the COVID-19 transmission, we employ an event study approach. We first examine the market responses to the two events. To that end, we follow the standard procedure of event study approach. We use ordinary least square (OLS) to estimate a market model over a 180-day estimation window with Hushen300 index as the market return, and we estimate the average cumulative abnormal returns (CARs) over the corresponding event window centered on a particular event date. To better understand the underlying mechanisms, we then conduct regression analysis to examine the determinants of the CARs.

2.2.1. Event dates

To implement our event study, we first identify the effective event dates. We consider two symbolic events. The first one is China’s announcement of lockdown of its Hubei province on January 23, 2020. This announcement was made at 0:00 am of that day, and the implementation of this lockdown started at 10:00 am of the same day. This announcement was unexpected and served as a wakeup call. It delivered a clear message to market participants about the severity of the outbreak of the disease in the epicenter and the potential of spreading to other Chinese provinces.

The second effective event date is February 24, 2020. The previous trading day is February 21. Two important pieces of news arrived during the weekend preceding that event date. First, as shown in Fig. 1, number of newly confirmed cases in China hit record low for three consecutive days (February 21 –February 23). Outside Hubei, the numbers dropped to 31, 18, and 11 in these three days, and those inside Hubei also fell significantly from over one thousand to less than four hundred. These numbers suggested that the disease became containable inside China. Second, there was also new development overseas. The newly confirmed cases in Italy started to rise, and amid a potential large outbreak, the Italian authority announced on February 23 a strict lockdown of the Lombardy region. In the U.S., officials from the Centers for Disease Control and Prevention (CDC) warned on February 21 that although the agency is taking historic measures to slow the introduction of COVID-19 into the United States, the country should prepare for the possibility of community spread. Due to the time difference, this accouchement was also news to market participants in China. News from overseas thus consistently indicate a likely outbreak in other parts of the world.

2.2.2. Regression model specification

We examine the determinants of firms’ heterogeneous responses by regressing the estimated firm CARs obtained from each event on firm characteristics. Specifically, we consider the following empirical model:

\[ y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \epsilon \]
where \( \text{CAR}_i \) is the cumulative abnormal return of a firm \( i \). \( C_i \) represents a set of firm-level control variables, including the log of total assets (LN_ASSET), the log of number of employees (LN_EMP), leverage ratio (LEVERAGE), and a state ownership dummy (SOE). In addition, we also consider three corporate governance measures, the log of total number of board members (LN_BOARD), the share of independent board members (INDEP), and a CEO-Chairperson duality dummy (DUALITY). \( \varphi_j \) and \( \varphi_k \) are industry and province fixed effects, respectively. The inclusion of these fixed effects helps control for the potential unobserved industry or province heterogeneity. 3

Our main variables of interest are \( \text{Hubei exposure} \) and \( \text{Foreign exposure} \). The former represents a firm’s exposures to Hubei, the epicenter of the disease in China, and the latter reflects a firm’s involvement in international trade or FDI activities. To capture the potential roles of both a firm’s internal network and the between-firm I-O linkages in determining its exposures, we consider two sets of indicators for each exposure measure. The first set of indicators is based on within-firm internal networks across different regions (nations). Specifically, we use whether a firm has any subsidiary in Hubei as a proxy of its Hubei exposure. 4 For foreign exposure, we use a firm’s exports (as a share of total sales) and its foreign direct investment (FDI) (as a share of total assets or sales) as proxies.

The second set of indicators reflects between-firm I-O linkages. Since we do not have detailed firm-level Hubei-related transaction information, we make use of China’s 2012 province-sector level IO table to compute the industry-level input and output shares of Hubei province for each firm to measure its Hubei exposure from the perspective of production network. For I-O based foreign exposure measure, we can obtain a firm’s detailed imports of intermediate inputs from the custom data. We thus use the value of intermediate input imports scaled by sales as a firm’s foreign exposure measure. In our empirical analysis, we will consider both sets of indicators. Our baseline regressions use the Hubei subsidiary dummy and firm exports to proxy a firm’s Hubei and foreign exposures, respectively. We also use other measures to check the robustness of our results.

3. Empirical results

3.1. Market responses

To compute the effects of the two events, we consider a narrow window for each event to avoid noises from other events. Specifically, we consider a 2-day (−1,0) event window for the first event and a 3-day (−11) window for the second event. We use a 2-day

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3 Since Wuhan has a specific industry strength in the automobile industry, in addition to the inclusion of industry fixed effects, we also conduct a robustness check in which we exclude the automobile industry from the sample. Our main findings are not affected.

4 To construct this Hubei exposure measure, we have to exclude firms headquartered in Hubei. To ensure the robustness of our results, we conduct a robustness check in which we exclude the Hubei exposure measure from the regressions but add all Hubei firms back to the sample. While not reported, we find that our results on foreign exposures are not affected.
instead of a 3-day window for the first event because of a ten-day suspension of trading due to the Chinese New Year holidays right after the first event date. A 2-day window, therefore, can prevent our results from being contaminated by other events occurred during the 10-day market closure period.

We find that, overall, the market responded negatively to the first event but positively to the second. Following the first event, 1423 out of the 2363 firms experienced a negative CAR. The two daily CARs, CAR(−1) and CAR(0) are −0.42% and −0.11%, respectively. The CAR over the two day window is −0.53%, and the parameter t-test result indicates it is significantly different from zero. The group mean of negative CAR is −2.62% and that of positive CAR is 2.63%. On the other hand, stock market responded significantly positively to the second event. In this case, 1335 out of the 2363 firms experienced a positive CAR. The three daily CARs, CAR(−1), CAR(0) and CAR(1) are 1.1%, 1.7% and 0.07%, respectively. The CAR over the 3-day event window is economically large, with a magnitude of 2.84%, and a parameter t-test suggests that it is statistically significant. The group mean, for the second event, of the negative CAR is −2.30% and positive CAR is 6.79%. The initial negative and later positive stock market responses are consistent with the dynamics of the disease in China.

3.2. Baseline regression results

We have shown that stock market overall responded negatively (positively) to the first (second) event. In this subsection, we explore further firm heterogeneity. We do so by estimating Eq. (1) for each event using the CARs obtained from our event study analysis as the dependent variable.

Table 1 reports the baseline regression results. The first two columns use the CARs from the first event, the lockdown of Hubei province, as the dependent variables. Column (1) regresses CARs on the Hubei and foreign exposure measures controlling only for industry and province fixed effects. In Column (2), we also include firm-level controls to the regression. We find that our measure of a firm’s Hubei exposure, a Hubei subsidiary dummy, has a significantly negative effect on a firm’s CAR following the lockdown of Hubei province. The estimated coefficients on this variable carry a minus sign and are statistically significant in the two columns. The estimated effect is also quantitatively sizable. For example, the estimated coefficient in Column (2) suggests that having a subsidiary in Hubei province is associated with a return of 0.6 percentage point lower. This finding is consistent with the notion that firms have operations in the epicenter of the disease were hit particularly hard by the outbreak of COVID-19.

On the other hand, we find that foreign exposure, proxied by exports as a share of total sales, has a significantly positive effect on firm returns. The estimated effects are positive, statistically significant, and also economically meaningful. For instance, the results shown in Column (2) indicate that a one-standard-deviation increase in foreign exposure raises a firm’s CAR by 0.3 percentage point. This result is consistent with investors’ then belief that the outbreak of the disease was mainly domestic. Foreign diversification thus should have a value-enhancing effect (e.g., Caselli, Koren, Lisicky, & Tenreyro, 2020). As for control variables, we find that employment size is associated with a higher CAR while leverage and board size are negatively related to CAR. Other controls are statistically insignificant.

In Columns (3) and (4) of Table 1, we conduct the same regression exercises but using the CARs from the second event as the dependent variable. The results suggest that Hubei exposure no longer has any significant effect on returns. This is consistent with the fact that there was no significant Hubei-specific news between the last trading day, February 21, and the event date, February 24. Interestingly, we also find that the coefficients on foreign exposure now become negative and significant, meaning that firms with a higher export to sales ratio have significantly lower returns. Quantitatively, a one-standard-deviation increase in the exports to sales ratio lowers CAR by about 0.28 percentage point. The combination of the containment of the disease in China and its outbreak overseas puts firms with a larger foreign exposure at a disadvantage.

3.3. Robustness checks

To ensure the robustness of our main findings, we conduct a set of sensitivity analyses in this subsection. The results are reported in Table 2. For the sake of space saving, we now only report the results on our main variables of interest. The dependent variables in Panels A and B are the CARs from the first and second event, respectively. First, in Column (1) of each panel, we use a firm’s foreign direct investment as an additional proxy of its foreign exposure and examine its impact on firm returns. We scale the value of a firm's FDI by its total assets and include it in Eq. (1) as an additional regressor. While the estimated coefficient on this additional variable is not significant in Panel A, it is significantly negative in Panel B. That is, as the disease spread to overseas, firms with a larger foreign direct investment experience a lower CAR.

Second, we consider alternative measures of a firm’s Hubei exposure. The results are reported in Columns (2) and (3) of each panel.

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5 The market closure started from January 24, 2020 and lasted till February 2, 2020. It re-opened on February 3, 2020.
6 Most industries responded negatively to the Hubei lockdown. Only 17 out of 71 industries had a positive CAR. These industries include: accommodation (0.84%), manufacture of chemical fibers (0.24%), recycling and disposal of waste (1.76%), construction of buildings (0.37%), news and publishing (0.27%), water transport (0.64%), production and supply of water (0.16%), electric equipment and machinery (0.63%), leather, furs and related products (0.33), processing of petroleum, coking, processing of nuclear fuel (0.19%), leasing (2.82%), manufacture of communication equipment, computers and other electronic equipment (1.16%), smelting and pressing of ferrous metals (0.07%).
7 This number is obtained by multiplying the standard deviation of the Hubei exposure measure by the estimated coefficient.
8 The results are not affected if we scale it by sales.
Instead of using a Hubei subsidiary dummy, Column (2) now uses the number of Hubei subsidiaries (in natural log) as a proxy of Hubei exposure. Using this alternative measure does not alter our main findings. The estimated effect of Hubei exposure remains significantly negative in the first event but insignificant in the second event. In Column (3), we conduct a similar exercise and use a Wuhan subsidiary dummy that takes the value of unity if a firm has any subsidiary in Wuhan, the city that was hit hardest by the disease. Again, we find that our main findings are not sensitive to this alternative measure.

Our third set of robustness checks is to consider different market benchmarks. In Column (4) of Table 2, we use value weighted average return as market benchmark and re-estimate the baseline regressions. In the last column, we also consider a three-factor model (i.e., adding the size factor and book-to-market factor as two additional factors). Using alternative market benchmarks does not change our main findings either.

Next, we also consider an alternative second event date. Specifically, we consider March 13, 2020 as the alternative event date. On that day, the U.S. announced a state emergency over the COVID-19 and freed up as much as 50 billion USD to assist citizens affected by the outbreak. The results from this alternative event date are reported in the last column of Panel B. They are consistent with our main findings.

So far, our measures of Hubei and foreign exposure are based mainly on within-firm internal network such as subsidiary information and foreign direct investment. In Table 3, we consider further measures based on between-firm I-O production linkages. Since we do not have information about firms' Hubei sales or imports from Hubei, we previously rely on subsidiary information to measure firms' Hubei exposure. Here, to proxy a firm's Hubei exposure from the perspective of production network, we make use of China's 2012 input-output table and calculate the total share of inputs coming from Hubei and outputs sold to Hubei for each industry (HB_share). Since this input-output based measure is only available at the industry level, we are not able to control for industry fixed effects in the regressions. Instead, we include a set of industry-level controls in the regressions, including industry wage to sales ratio and industry output (in natural log) as additional controls.

Columns (1) and (2) report the regression results using CARs obtained from the first event and the second event, respectively. The evidence suggests that I-O based production linkages are also important in the transmission of shocks. The estimated coefficient on the new measure of Hubei exposure is found to be negative and statistically significant in Column (1), indicating that firms that have a tighter I-O linkage with Hubei experienced a significantly lower return following the lockdown of Hubei. The estimated coefficient in the second event regression remains insignificant. The results on the foreign exposure measure, exports to sales ratio, are also consistent with our previous results.

In the next two columns, we separate the industry share of inputs coming from Hubei (HB_input_share) from that of outputs sold to Hubei (HB_output_share) and include both shares in the regressions. The results in Column (3) indicate that it is the share of outputs sold to Hubei that matters significantly. The coefficient on this share is negative and significant while that on the share of inputs coming from Hubei is statistically insignificant.

### Table 1
Baseline regression results.

|                | Dep = CAR_event1 | Dep = CAR_event2 |
|----------------|------------------|------------------|
| (1)            | (2)              | (3)              | (4)              |
| HB_sub         | −0.0036**        | −0.0056***       | 0.0031           | 0.0066           |
|                | (0.002)          | (0.001)          | (0.006)          | (0.005)          |
| EXP/SALES      | 0.0055***        | 0.0061***        | −0.0056***       | −0.0064***       |
|                | (0.002)          | (0.001)          | (0.001)          | (0.001)          |
| LN_ASSETS      | 0.0009           | −0.0071*         | 0.0034           | 0.0004           |
|                | (0.001)          | (0.003)          | (0.003)          | (0.004)          |
| LN_EMP         | 0.0025***        | 0.0007           | −0.0097*         | −0.0042           |
|                | (0.001)          | (0.002)          | (0.005)          | (0.006)          |
| LEVERAGE       | −0.011           | 0.0012           | 0.0011           | 0.0007           |
|                | (0.025)          | (0.013)          | (0.021)          | (0.025)          |
| INDEP          | −0.0153          | −0.0071*         | −0.0007          | −0.0016          |
|                | (0.013)          | (0.002)          | (0.005)          | (0.006)          |
| DUALITY        | 0.0000           | 0.0007           | −0.0090*         | −0.0029           |
|                | (0.005)          | (0.002)          | (0.005)          | (0.006)          |
| LN_BOARD       |                 |                  |                  |                  |
| Industry F.E.  | Yes              | Yes              | Yes              | Yes              |
| Province F.E.  | Yes              | Yes              | Yes              | Yes              |
| Observations   | 2289             | 2250             | 2289             | 2250             |
| R-squared      | 0.070            | 0.077            | 0.138            | 0.148            |

**Notes:** The dependent variables in Columns (1) and (2) are the CARs for the first event, and that in Columns (3) and (4) are the CAR for the second event. HB_sub is a dummy variable equals 1 if a firm has any subsidiary in Hubei province. EXP/SALES is firm’s export value as a share of total sales. Control variables include LN_ASSETS, LN_EMP, LEVERAGE, SOE, INDEP, DUALITY and LN_BOARD. A constant, industry fixed effects and province fixed effects are included in each regression. Standard errors clustered at the industry level are reported in the parentheses. *, ** and *** denote the 10, 5 and 1% significance levels, respectively.
Finally, in Columns (5) and (6) of Table 3, we further include a firm’s imports of intermediate inputs scaled by total sales (INT_IMP/SALES) in our baseline regressions to capture the potential impacts of reliance on foreign input supplies. Controlling for exposure to foreign supply of inputs does not affect our previous findings. Hubei exposure is still significantly negative in Column (5) and remains insignificant in Column (6). Similarly, foreign sales exposure is again found to be significantly positive in Column (5) and significantly negative in Column (6), respectively. The estimated coefficients on imports of intermediate inputs are found to be insignificant in both columns.

### 3.4. Heterogeneity

In this subsection, we further explore some potential heterogeneity to see if the effects of Hubei and foreign exposures vary across some key firm or industry characteristics. We first explore the potential heterogeneity related to firm ownership. We interact our baseline measures of Hubei and foreign exposures, the Hubei subsidiary dummy and exports to sales ratio, with a state-ownership dummy and include the interaction terms in our regressions as additional regressors. The results are reported in Columns (1) and (2) of Table 4. The inclusion of the interaction terms does not change our previous findings. In addition, we find that the coefficient on the interaction term between the Hubei subsidiary dummy and state-ownership is significantly positive in the first event regression, implying that state-owned firms suffered less from a Hubei exposure after the domestic outbreak. The interaction terms between exports and state ownership are insignificant in both columns.

In the next two columns, we explore further a potential industry heterogeneity. Specifically, we interact our foreign exposure measure with a pharmaceutical industry dummy (PHARMA) and include the interaction term in the regressions. We find that, interestingly, the interaction term is negative and significant during the first event but positive and significant during the second event.

#### Table 2

**Robustness checks.**

| Panel A | (1) | (2) | (3) | (4) | (5) |
|---------|-----|-----|-----|-----|-----|
| Dep = CAR_event1 | Add FDI | Hubei number | Wuhan dummy | Value Weighted | 3 Factor Model |
| HB_sub | $-0.0056^{***}$ | $-0.0056^{***}$ | $-0.0056^{***}$ | (0.001) | (0.002) | (0.002) |
| FDI/ASSETS | $-0.0050$ |  |  | (0.003) |  |  |
| LN_HB_number |  | $-0.0025^{**}$ |  | (0.001) |  |  |
| Wuhan_sub | $0.0061^{***}$ | $0.0062^{***}$ | $0.0061^{***}$ | (0.001) | (0.001) | (0.001) |
| EXP/SALES |  |  | $0.0060^{***}$ |  | (0.001) | (0.001) |
| Industry F.E. | Yes | Yes | Yes | Yes | Yes |
| Province F.E. | Yes | Yes | Yes | Yes | Yes |
| Observations | 2250 | 2250 | 2250 | 2250 | 2250 |
| R-squared | 0.078 | 0.075 | 0.077 | 0.079 | 0.080 |

| Panel B | (1) | (2) | (3) | (4) | (5) | (6) |
|---------|-----|-----|-----|-----|-----|-----|
| Dep = CAR_event2 | FDI | Hubei number | Wuhan dummy | Value Weighted | 3 Factor Model | Alternative event date |
| HB_sub | 0.0067 | 0.0068 | 0.0065 | (0.005) | (0.005) | (0.004) |
| FDI/ASSETS | $-0.0128^{***}$ | $-0.0128^{***}$ | $-0.0128^{***}$ | (0.004) | (0.004) | (0.004) |
| LN_HB_number | 0.0025 | 0.0025 | 0.0066 | (0.004) | (0.004) | (0.004) |
| Wuhan_sub |  |  |  | (0.005) | (0.005) | (0.005) |
| EXP/SALES | $-0.0064^{***}$ | $-0.0064^{***}$ | $-0.0064^{***}$ | (0.001) | (0.001) | (0.001) |
| Industry F.E. | Yes | Yes | Yes | Yes | Yes | Yes |
| Province F.E. | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2250 | 2250 | 2250 | 2250 | 2250 | 2244 |
| R-squared | 0.149 | 0.147 | 0.148 | 0.145 | 0.107 | 0.082 |

Notes: The dependent variables in Panel A are CARs for the first event, and those in Panel B are CARs for the second event. We proxy Hubei exposure using the number of Hubei subsidiaries (in natural log) labeled as LN_HB_number in Columns (2) and a dummy variable that takes the value of unity if a firm has any subsidiary in Wuhan labeled as Wuhan_sub in Columns (3). We use value-weighted average return in the Columns (4) and a three-factor model in Columns (5). In Column (6), we consider one alternative event date. HB_sub is a dummy variable equals 1 if a firm has any subsidiary in Hubei province. FDI/ASSETS is firm’s greenfield foreign direct investment value as a share of total assets. EXP/SALES is firm’s export value as a share of total sales. Control variables include LN_ASSETS, LN_EMP, LEVERAGE, SOE, INDEP, DUALITY and LN_BOARD. A constant, industry fixed effects and province fixed effects are included in each regression. Standard errors clustered at the industry level are reported in the parentheses. *, ** and *** denote the 10, 5 and 1% significance levels, respectively.
During the domestic outbreak of the disease, firms in the pharmaceutical industry that sell more to the domestic market have a relatively higher return compared to firms relying more on foreign demand. Following the overseas outbreak, however, pharmaceutical firms that sell more to foreign markets benefit more due to an expected strong foreign demand for pharmaceutical products. These results are consistent with a relative increase in domestic (foreign) demand for pharmaceutical products following the first (second) event.

In Table 5, we explore the heterogeneity across online and offline business. Specifically, we create a dummy variable “ONLINE” for online business industry which takes the value 1 if the firms belong to internet and related online business services sector, or computers, telecommunication and other electronic equipment manufacturing sector, and 0 otherwise. In columns (1) and (3) of Table 5, we include ONLINE as a regressor in the regressions without including the industry fixed effects. The positive and significant coefficients for both events reflect a significantly more positive CAR for this industry due to high demand for online business during the pandemic. Moreover, in columns (2) and (4) of Table 5, we also interact our foreign exposure measure with the ONLINE industry dummy and include the interaction term in the regressions while controlling for the industry fixed effects. The negative and significant

### Table 3
I-O linkage based Hubei and foreign exposure measures.

| Dep. Variable | (1) CAR_event1 | (2) CAR_event2 | (3) CAR_event1 | (4) CAR_event2 | (5) CAR_event1 | (6) CAR_event2 |
|---------------|----------------|----------------|----------------|----------------|----------------|----------------|
| HB_share      |                |                |                |                |                |                |
|               | −0.0065***     |                |                |                | −0.0056***     |                |
|               | (0.001)        |                |                |                | (0.001)        |                |
| HB_input share|                |                |                |                |                |                |
|               |                | −0.0064***     |                | −0.0064***     |                |                |
|               |                | (0.005)        |                | (0.005)        |                |                |
| HB_output share|                |                |                |                |                |                |
|               |                |                | −0.0018***     |                |                |                |
| EXP/SALES     | 0.0061***      |                | −0.0064***     |                | 0.0062***      | −0.0072***     |
|               | (0.001)        |                | (0.001)        |                | (0.001)        |                |
| HB_sub × SOE  | 0.0114***      |                | 0.0025         |                | 0.2253***      |                |
|               | (0.004)        |                | (0.012)        |                | (0.004)        |                |
| EXP/SALES × SOE|                |                | −0.0183        |                |                |                |
|               |                |                | (0.043)        |                |                |                |
| EXP/SALES × PHARMA |                |                | −0.0125***      |                |                | 0.2253***      |
|               |                |                | (0.003)        |                |                | (0.004)        |
| Controls      | Yes            | Yes            | Yes            | Yes            | Yes            | Yes            |
| Industry F.E. | No             | No             | No             | No             | No             | No             |
| Province F.E. | Yes            | Yes            | Yes            | Yes            | Yes            | Yes            |
| Observations  | 2250           | 2250           | 2250           | 2250           | 2250           | 2250           |
| R-squared     | 0.045          | 0.084          | 0.045          | 0.084          | 0.086          | 0.046          |

Notes: The dependent variables in Columns (1), (3) and (5) are CARs for the first event, and those in Columns (2), (4) and (6) are CARs for the second event. HB_share is the input and output share of Hubei Province. HB_input_share and HB_output_share represent input and output share of Hubei province, respectively. EXP/SALES is firm’s export value as a share of total sales and FDI/ASSETS is firm’s greenfield foreign direct investment value as a share of total assets. Firm-level control variables include LN_ASSETS, LN_EMP, LEVERAGE, SOE, INDEP, DUALITY and LN_BOARD. Industry-level controls include INDWAGE_RATIO and LN_INDOUTPUT. A constant and province fixed effects are included in each regression. Standard errors clustered at the industry level are reported in the parentheses. *, ** and *** denote the 10, 5 and 1% significance levels, respectively.

During the domestic outbreak of the disease, firms in the pharmaceutical industry that sell more to the domestic market have a relatively higher return compared to firms relying more on foreign demand. Following the overseas outbreak, however, pharmaceutical firms that sell more to foreign markets benefit more due to an expected strong foreign demand for pharmaceutical products. These results are consistent with a relative increase in domestic (foreign) demand for pharmaceutical products following the first (second) event.

In Table 5, we explore the heterogeneity across online and offline business. Specifically, we create a dummy variable “ONLINE” for online business industry which takes the value 1 if the firms belong to internet and related online business services sector, or computers, telecommunication and other electronic equipment manufacturing sector, and 0 otherwise. In columns (1) and (3) of Table 5, we include ONLINE as a regressor in the regressions without including the industry fixed effects. The positive and significant coefficients for both events reflect a significantly more positive CAR for this industry due to high demand for online business during the pandemic. Moreover, in columns (2) and (4) of Table 5, we also interact our foreign exposure measure with the ONLINE industry dummy and include the interaction term in the regressions while controlling for the industry fixed effects. The negative and significant

### Table 4
Heterogeneity across ownership and industry.

| Dep. Variable | (1) CAR_event1 | (2) CAR_event2 | (3) CAR_event1 | (4) CAR_event2 |
|---------------|----------------|----------------|----------------|----------------|
| HB_sub        |                |                |                |                |
|               | −0.0018***     |                |                |                |
|               | (0.001)        |                |                |                |
| EXP/SALES     |                | −0.0018***     |                |                |
|               |                | (0.001)        |                |                |
| HB_sub × SOE  | 0.0025         |                | 0.0025         |                |
|               | (0.012)        |                | (0.012)        |                |
| EXP/SALES × SOE|                |                | −0.0183        |                |
|               |                |                | (0.043)        |                |
| EXP/SALES × PHARMA |                |                | 0.0125***      |                |
|               |                |                | (0.003)        |                |
| Controls      | Yes            | Yes            | Yes            | Yes            |
| Industry F.E. | Yes            | Yes            | Yes            | Yes            |
| Province F.E. | Yes            | Yes            | Yes            | Yes            |
| Observations  | 2250           | 2250           | 2250           | 2250           |
| R-squared     | 0.045          | 0.084          | 0.045          | 0.084          |

Notes: The dependent variables in Columns (1) and (3) are CARs for the first event, and those in Columns (2) and (4) are CARs for the second event. HB_sub is a dummy variable equals 1 whether a firm has any subsidiary in Hubei province. EXP/SALES. EXP/SALES is firm’s export value as a share of total sales. SOE and PHARMA are dummy variables for state ownership and pharmaceutical industry, respectively. Control variables include LN_ASSETS, LN_EMP, LEVERAGE, INDEP, DUALITY and LN_BOARD. A constant, industry fixed effects and province fixed effects are included in each regression. Standard errors clustered at the industry level are reported in the parentheses. *, ** and *** denote the 10, 5 and 1% significance levels, respectively.
coefficient for the first event evidence that online business with more domestic sales benefit more from the positive demand shock during the Wuhan lockdown. However, the coefficient on the interaction is insignificant for the second event. A probable reason for this disparity could be that online business mainly covers the domestic market.

4. Discussions

After presenting our empirical results, in this section, we provide some further discussions on the comparison of our findings with existing literature, the implications of our study, as well as some potential areas for future research.

Our study contributes to the relevant literature in the following aspects. First, our work is related to the literature on economic outcomes of disease or health shocks (e.g., Bleakley, 2007; Bloom, Canning, & Sevilla, 2004; Foster, 1995; Nunn & Qian, 2010; Strauss & Thomas, 1998; Well, 2007; Zhang, Zhang, & Lee, 2003). In particular, a recently-emerged strand of literature has started to examine the impact of COVID 19 on firm values using stock market data from both developing countries (e.g., Ali, 2020; Alam, Alam, & Chavali, 2020; He, Sun, Zhang, & Li, 2020) and developed economies (e.g., Alam, Wei, & Wahid, 2020; Heyden & Heyden, 2021). Existing studies typically find that firms responded negatively in the stock markets returns after the domestic lockdown or announcement of the outbreak of COVID-19. Moreover, there is a great variation among the sectors and the pharmaceutical and healthcare industries are found to be resilient to the COVID-19 pandemic. As shown in Section 3, our findings on the negatively significant valuation effects after the lockdown of Hubei province as well as the heterogeneity across industries are quite consistent with the extant literature. More importantly, we fill the gap in the literature by tackling the role of firms’ international status, internal networks and input-output linkages in determining their exposures to the pandemic, which are important yet unexplored.

Second, our work also fits into a narrow but growing strand of literature that studies the effects of COVID-19 related to China. For example, Fang, Wang, and Yang (2020) study the effect of human mobility restrictions on spread of COVID-19 in China. Fang and Yeung (2020) examine how COVID-19 affect global value chains and its implications for China. Ru, Yang, and Zou (2020) show that governments in countries that have experienced SARS respond significantly faster in implementing containment measures to combat COVID-19 than countries that have not experienced SARS. Our study focuses on the valuation effects of COVID-19 on Chinese firms.

Third, we also contribute to the literature that studies the effects of firms’ international status (e.g., Denis, Denis, & Yost, 2002; Desai & Hines Jr, 2008; Baker, Foley, & Wurgler, 2008; Fillat & Garetto, 2015; and Caselli et al., 2020). Existing contributions document that, on the one hand, a negative shock abroad can be a source of risk exposure to firms. On the other hand, internationalization can also have a valuable diversification effect by reducing exposure to adverse domestic shocks. Our finding that a firm’s foreign exposure has different effects following the two events is consistent with the main message from this literature.

Finally, our work is related to the broad literature that examines the role of networks in the transmission of shocks within and between firms. Two strands of literature fall into this category. One strand focuses on firm internal network (e.g., Antràs, 2003; Garetto, 2015; and Caselli et al., 2020). Existing contributions examine the role of international status, internal networks and input-output linkages in determining their exposures to a pandemic. The other examines the role of between-firm I-O linkages (e.g., Acemoglu, Carvalho, Ozdaglar, & Tahbaz-Salehi, 2012; Ahn, Khandelwal, & Wei, 2011; Barrot & Sauvagnat, 2016; Boehm, Flaaen, & Pandalai-Nayar, 2019; Carvalho, 2014; Hertzel, Li, Officer, & Rodgers, 2008; Kee & Tang, 2016; Wang, Wei, Yu, & Zhu, 2017 and Wei & Xie, 2020). Our findings complement the two strands of literature by showing that both are important in determining firms’ exposures to a pandemic.

Our study on the valuation effects of COVID-19 pandemic as well as the underlying mechanisms also have important implications. First, the findings are meaningful for equity investors and business managers. Our results suggests that should pay special attention on

### Table 5

| Variables          | (1)       | (2)       | (3)       | (4)       |
|--------------------|-----------|-----------|-----------|-----------|
|                    | CAR_event1 | CAR_event1 | CAR_event2 | CAR_event2 |
| ONLINE             | 0.0139***  | –0.0180*** | 0.0485***  | –0.0012*** |
| EXP/SALES × ONLINE | (0.004)    | (0.004)    | (0.008)    | (0.003)    |
| HB_sub             | –0.0062*** | –0.0055*** | 0.0076     | 0.0066     |
| EXP/SALES          | (0.001)    | (0.001)    | (0.005)    | (0.005)    |
| EXP/SALES × ONLINE | 0.0066***  | 0.0067***  | –0.0049*** | –0.0064*** |
| Controls           | Yes       | Yes       | Yes       | Yes       |
| Industry F.E.      | No        | Yes       | No        | Yes       |
| Province F.E.      | Yes       | Yes       | Yes       | Yes       |
| Observations       | 2250      | 2250      | 2250      | 2250      |
| R-squared          | 0.043     | 0.079     | 0.102     | 0.148     |

**Notes:** The dependent variables in Columns (1) and (2) are CARs for the first event, and those in Columns (3) and (4) are CARs for the second event. HB_sub is a dummy variable equals 1 whether a firm has any subsidiary in Hubei province. EXP/SALES × EXP/SALES is firm’s export value as a share of total sales. ONLINE is a dummy variable for online related industry. Control variables include LN_ASSETS, LN_EMP, LEVERAGE, INDEP, DUALITY and LN_BOARD. A constant, industry fixed effects and province fixed effects are included. Standard errors clustered at the industry level are reported in the parentheses. *, ** and *** denote the 10, 5 and 1% significance levels, respectively.
the investment diversification when making investment decisions especially with the rising uncertainty in the international trade and investment environment. Second, our study on the determinant role of a firm’s international status, internal networks, and I-O linkages in its exposures to the health shock further indicates that internationalization can be a useful instrument for firms to reduce their exposures to adverse domestic shocks. Third, the heterogeneity analyses are also vital for policymakers that they should take precautions on vulnerable sectors and develop recovery action plans accordingly to enable market participants to regain their confidence in case of an emergent public health crisis.

Future research could leverage the findings in this paper in a number of ways. First, trying to find out the long-term effect of COVID-19 pandemic would provide more implication for our understanding of the factors determining firm value. However, due to lack of data as the pandemic is only a recent event from 2020, we are still unable to address that yet. Furthermore, in our study, we resort to the province-sector level IO table to approximate the firm-level IO linkage network as we do not have access to the disaggregated Chinese firm-level data for the IO linkage. However, the results might be confounding as the firm-level effects could be entangled with the industry fixed effects. We think it worth further discussions on disentangling the effect of firm-level linkage network in future studies, with the disaggregated firm-level linkage network statistics available. In addition, although we found a substantial amount of firm heterogeneity, how and to what extent the impacts of COVID-19 will transmit across industries and regions are still under investigation. These questions undoubtedly deserve further attentions as more data become available.

5. Conclusions

Using the COVID-19 pandemic and an event study approach, we provide evidence that a large negative health shock can have significant impacts on firms, and the effects vary across different phases. Chinese stock market responded significantly negatively to the domestic outbreak of the disease but significantly positive to the containment of the disease in China and the outbreak overseas. Further regression analysis suggests that there is a substantial amount of firm heterogeneity. Firms with a larger degree of Hubei exposure earned a significantly lower return following the first event. A higher degree of foreign exposure has a value-enhancing diversification effect following the domestic outbreak of the disease but a value-destroying effect after an overseas outbreak. Our results suggest that a firm’s international status, its internal networks and input-output based production network are important determinants of its exposure to the pandemic in a globalized world.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chieco.2021.101721.

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