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Vertical integration and corporate value under uncertainty shock: Evidence from the COVID-19 pandemic

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\textbf{ABSTRACT}

Using the exogenous shock of the COVID-19 pandemic, we examine whether vertical integration creates value for firms when facing increasing uncertainty. Using cross-sectional data during the outbreak of the COVID-19 pandemic, we find that there is a significant and positive correlation between vertical integration and cumulative abnormal return in the event window of the COVID-19. Furthermore, when external transaction costs are higher or internal organization costs are lower during the COVID-19 pandemic, the above results are more pronounced. Our results indicate that vertical integration could avoid uncertainty, reduce transaction costs, hence improving corporate value, providing empirical evidence for theories about the uncertainty and vertical integration in transaction-cost economics.

\section{1. Introduction}

According to transaction-cost economics, the key to the impact of vertical integration on corporate value lies in whether vertical integration can reduce transaction costs (Coase, 1937). Williamson (1979) measures transaction costs in three dimensions: asset specificity, uncertainty and transaction frequency. Among them, uncertainty refers to the interference of unexpected external environmental changes on transactions (Leiblein and Miller, 2003), and it is considered as the key factor affecting the organizational value. The adaptive capacity to uncertainties is considered as the fundamental standard for evaluating organizations (Thompson, 1967). Williamson (1985) points out that many important issues involved in transaction-cost economics could be reduced to evaluating the adaptability of different organizational structures (i.e., the enterprise or the market) to external interference. Therefore, it is an important economic issue whether vertical integration can improve firm adaptability to uncertainty and enhance corporate value. However, the empirical research on that issue is scarce, with mixed evidences. Therefore, it is necessary to find a suitable scenario to investigate the impact of vertical integration on corporate value under the uncertainty shock.

The outbreak of the COVID-19 pandemic in early 2020 provides a natural experiment for examining the impact of vertical integration on corporate value under the uncertainty shock. Compared with previous public crises, this pandemic spreads quickly and widely, and is difficult to be prevented and controlled. It could be characterized by suddenness, unpredictability and high risks (Ding et al., 2021). The COVID-19 pandemic is a typical exogenous event. As the future development, duration and the final impact on the economy of the COVID-19 pandemic are uncertain, the prevention and control policies are in dynamic adjustment. In addition, the behaviors of market players under the shock of the pandemic are highly uncertain (Ramelli and Wagner, 2020). Therefore, the pandemic

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increases the uncertainty for firms rapidly (Hassan et al., 2021; Ramelli and Wagner, 2020), thus providing following advantages for studying the impact of vertical integration on corporate value under the uncertainty shock. First, Exogeneity. For firms and the capital market, the COVID-19 pandemic is an exogenous shock, which is independent of corporate characteristics such as management level, business scope and financial status that may affect both vertical integration and corporate value. Second, suddenness and unpredictability. The sudden COVID-19 pandemic means that firms cannot adjust in advance the characteristics of corporate management such as development strategies and supply chain management. What is more, at the beginning of the COVID-19 pandemic, its future development and duration, as well as its final impact on macro-economy and firms are highly uncertain, and the prevention and control policies (e.g., whether the government will issue policy restricting the production, transportation and operation of firms, and how long the policy will last) are also uncertain, which mean that the external uncertainty for firms suddenly increases, while firms’ business characteristics remain unchanged, thus allowing us to use the COVID-19 event to examine the impact of vertical integration on corporate value under the uncertainty shock. Third, influence of this pandemic is extensive. The COVID-19 pandemic influences all provincial areas and industries in China, which makes the samples of this study cover different regions and industries, thus ensuring the generality of the conclusions. Therefore, using the exogenous shock of the COVID-19 pandemic, this paper investigates the impact of vertical integration on corporate value under the uncertainty shock.

We use the event study method and January 20, 2020 when the National Health Commission of the People’s Republic of China declared the COVID-19 as a Class B infectious disease is selected as the event day, and the three trading days before and after the event day are regarded as the event window (i.e., [−3, +5]). Using cross-sectional data during the outbreak of the COVID-19 pandemic, we find that there is a significant and positive correlation between vertical integration and cumulative abnormal return in event window of the COVID-19, which indicates that when the external emergencies lead to the increased uncertainty for firms, the market generally favors firms with higher vertical integration. Further analysis shows that when external transaction costs for firms increase more (firms with higher asset specificity, lower status, and higher intensity of industry competition) or internal organization costs for firms increase less (firms with higher proportion of independent directors, higher shareholding ratio of management, and higher degree of equity restriction) due to the COVID-19 pandemic, the above results are more pronounced. Our results indicate that vertical integration can avoid uncertainty, reduce transaction costs, hence improving corporate value when the uncertainty increases.

This paper makes three main contributions to the literature. Firstly, this paper enriches the research on economic consequences of vertical integration. The existing studies are mainly static analysis (Buzzell, 1983; Fan and Lang, 2000; Wan and Sanders, 2017), which cannot identify causality effectively; and most of them focus on specific industries or even specific firms (Hanssen, 2010; Gil and Warzynski, 2015), which cannot ensure the generality of the research conclusions. Some studies use M&As as the research scenario, and investigate the wealth effect of vertical integration by analyzing the market reaction of vertical M&As (Spiller, 1985; Helfat and Teece, 1987; Kedia et al., 2009); however, M&As are not exogenous events, and the research conclusion cannot avoid the endogenous motivation of M&As or the interference of other unobservable features of M&As. In addition, as for the economic consequences of vertical integration, especially the impact of vertical integration on corporate value or performance under the uncertainty shock, the existing research has not reached consistent conclusions. Some studies believe that vertical integration can improve the firm adaptability under the uncertainty shock, and strengthen risk management and coordination, thus having a positive impact on corporate performance (Helfat and Teece, 1987; Hanssen, 2010; Gil and Warzynski, 2015; Wan and Sanders, 2017). Some studies believe that vertical integrated firms lack flexibility in a face of a complex environment, which increases the risks, and has a negative impact on firm efficiency (D’Aveni and Ilinitch, 1992; Poppo and Zenger, 1998; Zhang, 2013). In addition, some studies find that vertical integration cannot create value for firms (Kedia et al., 2009). This paper examines the impact of vertical integration on corporate value under the uncertainty shock (the exogenous COVID-19 pandemic), enriching the research on economic consequences of vertical integration, especially those under the uncertainty shock.

Secondly, this paper contributes to the research about the impact of uncertainty on corporate vertical integration. The transaction cost is the key to determining vertical integration, and it is described by asset specificity, uncertainty and transaction frequency (Williamson, 1979). A large number of studies find that asset specificity promotes vertical integration (John and Weitz, 1988; Acemoglu et al., 2010; Fan et al., 2017), while there is little research on the impact of uncertainty on vertical integration (John and Weitz, 1988; Fan, 2000). Using the exogenous shock of the COVID-19 pandemic, this paper finds that when the uncertainty increases, the market generally favors firms with higher vertical integration, indicating that vertical integration can avoid uncertainty. This study reveals that uncertainty is an important factor for vertical integration, which enriches the research on the determinants of vertical integration.

Thirdly, this study supplements the research on the impact of public emergencies on the capital market. Some studies examine the economic consequences of SARS and flu outbreaks (Nippiani and Washer, 2004; McTier et al., 2013). With the outbreak of the COVID-19 pandemic, scholars investigate the impact of the pandemic on the capital market and different firms from different perspectives (e.g., corporate governance level, and firm size) (Baker et al., 2021; Ding et al., 2021; Hassan et al., 2021; Ramelli and Wagner, 2020). This
paper examines the impact of vertical integration on corporate value during the pandemic, which enriches the research on the impact of sudden public crises on capital market and firms.

2. Theoretical analyses and hypothesis development

We argue that under the shock of the uncertainty caused by the COVID-19 pandemic, vertical integration may have both positive and negative impacts on corporate value.

On the one hand, under the shock of the COVID-19 pandemic, vertical integration could enhance corporate value. At the beginning of the COVID-19 pandemic, firms’ business environment including the future trend of the pandemic and the prevention and control policies faces high uncertainty. The high uncertainty of the business environment means high transaction costs in the cooperation with external counterparties. Specifically, the shock of the COVID-19 pandemic means that the future situations become more complicated, such as whether mandatory restrictions will be imposed on the production and transportation links of firms according to the prevention and control policies, whether the possible shutdown will lead to a shortage of raw materials or a sharp drop in product demand, or even whether the raw materials will be in short supply or the demand for products will surge in a short time after the end of the pandemic. In order to ensure the smooth performance of contracts, vertically specialized firms need to make a lot of preparations such as prior consultation, negotiation and drafting for various possible situations in the future and different expectations of transaction parties for those situations before signing contracts with counterparties, which means that firms need to bear high costs before the signing of contracts. Once unexpected situations happen after the signing of contracts, transaction parties need to re-communicate, and coordinate and bargain for those unexpected situations, which means that firms need to bear high adjustment costs after the signing of contracts (Williamson, 1985). Vertical integration means that multiple production and operation links in the supply chain are under the same ownership, so that the transactions among firms are changed to be within the same firm, and the resource allocation is determined by the authority within the firm. Therefore, in the face of high uncertainty, firms with high vertical integration can make arrangements for the production, processing, storage and sales activities between internal upstream and downstream branches according to the actual situations, and make timely adjustments, without bearing high transaction costs of negotiation with counterparties as vertically specialized firms do (Williamson, 1985; Hansen, 2010). Moreover, the self-interest and opportunism incentive of economic agents make the transactions in market always face behavioral uncertainty (Williamson, 1985; Helfat and Teece, 1987), namely, the hold-up problem. The pandemic shock aggravates the behavioral uncertainty of transaction parties. Specifically, at the early stage of the pandemic, since the upstream and downstream markets are likely to halt production, specialized firms face a very high risk of disruption to supply chains. In this case, upstream or downstream firms are likely to carry out hold-up given the dependence of focal specialized firm on an external single counterparty at critical times. For example, suppliers may maliciously increase the prices of raw materials, and distributors may maliciously lower the prices of products to obtain excess profits (Du et al., 2012), which will cause high transaction costs for focal specialized firms. However, in a focal firm with high vertical integration, the upstream and downstream branches of it are managed and controlled by authorities of the same ownership, and each branch is not independent, so it is unlikely that opportunistic behaviors such as hold-up occur among the branches (Helfat and Teece, 1987), which is also true during the COVID-19 pandemic. Therefore, vertical integration can help firms avoid the transaction costs caused by hold-up of external counterparties, which will be highlighted during the pandemic.

To sum up, under the shock of uncertainty caused by the COVID-19 pandemic, firms with high vertical integration are less affected by the increased external transaction costs, so vertical integration could enhance corporate value.

On the other hand, under the shock of the pandemic, vertical integration may also reduce corporate value. Although vertical integration enables firms to avoid external transaction costs, firms with vertical integration have to undertake higher internal organization costs. Specifically, as the internal branches of vertically integrated firms are not independent agents, firms cannot carry out incentives as strong as the market does (Williamson, 1985), which leads to the phenomenon of insider’s laziness (Pénard et al., 2011; Fan et al., 2017), resulting in efficiency loss (D’Aveni and Ravenscraft, 1994), and high supervision and control costs for firms. Under the shock of the COVID-19 pandemic, since the poor performance can be attributed to the COVID-19 pandemic (Baginski et al., 2000), internal branches of vertically integrated firms may utilize the adverse impact of the pandemic on business operation as an excuse to reduce subjective efforts, thus aggravating the phenomenon of insider’s laziness and efficiency loss. Moreover, the higher structural complexity of vertically integrated firms leads to more serious information asymmetry between the management and shareholders, which means that the management has more opportunities to seek personal gains. In addition, the equity structure of listed firms in China is highly concentrated, and the control right and cash-flow right of major shareholders are severely deviated, which means that

According to The New York Times, during the COVID-19 pandemic, due to the decline of market demand and the increase of transportation costs, US dairy farmers dumped at least 10 million liters of milk every day. The waste of resources caused by dumping milk reflects the high external transaction costs for specialized firms under the uncertainty shock. In contrast, Modern Farming (Group) Co. Ltd., a large milk processing firm in China, has built a vertical integration mode of pasture planting, dairy farming, milk processing and sales, so it can coordinate the transportation and allocation of all links in the internal industrial chain in an orderly manner during the COVID-19 pandemic, and flexibly adjust the output and structure of products according to market demand (such as spray-drying of raw milk for storage), thus ensuring stable revenues to the greatest extent.

During the pandemic, Yichang Xinlong Sanitary Material Co., Ltd., a wholly-owned subsidiary of Xinlong Holding (Group) Co., Ltd. (stock code: 000955), raised the sales price of melt-blown non-woven fabric for several times from the original price of 12,700/ton to 350,000/ton, when the production cost did not increase much. Therefore, Yichang Xinlong Sanitary Material Co., Ltd. was punished by the local market supervision department. For details, please see the Decision of Administrative Punishment (No. 118, [2020] of Yindu Administration for Market Regulation).
major shareholders have the motivation and ability to carry out tunnelling (Shleifer and Vishny, 1997). The complex organizational structure and information asymmetry of vertically integrated firms provide further convenience for major shareholders to carry out tunnelling. Therefore, compared with specialized firms, firms with high vertical integration may generally have more serious agency problems. Under the shock of the COVID-19 pandemic, the cash flow of major shareholders is likely to slow down even stop, which means higher motivation of major shareholders for tunneling during the COVID-19 pandemic. In such a period of high uncertainty caused by the COVID-19 pandemic, stakeholders often neglect the supervision over firm management, making it possible for major shareholders and managers to grab personal resources (Djankov et al., 2008). In other words, the COVID-19 pandemic further aggravates the agency problems for firms with high vertical integration.

To sum up, under the shock of the uncertainty caused by the COVID-19 pandemic, firms with high vertical integration may also undertake higher internal organization costs, so vertical integration may reduce corporate value. According to the above analysis, following competitive hypotheses are developed:

H1a : under the shock of uncertainty caused by the COVID-19 pandemic, vertical integration is positively correlated with corporate value.

H1b : under the shock of uncertainty caused by the COVID-19 pandemic, vertical integration is negatively correlated with corporate value.

3. Research design

3.1. Sample selection and data sources

We take A-share listed firms in Shanghai Stock Exchange and Shenzhen Stock Exchange as the initial samples, and adopt the event study method to test the impact of vertical integration on the stock market reaction to the pandemic, so as to investigate changes in corporate value with different degree of vertical integration under the shock of the pandemic. We obtain corporate financial data from CSMAR. In order to improve the research validity, sample is selected by the following principles: (1) when estimating the abnormal return, we exclude firms with less than 180 trading days in the estimation window and firms with less than three trading days in the event window; (2) we eliminate observations with negative net assets; (3) we eliminate observations from financial industry; and (4) we eliminate observations with other missing values. Finally, firm-level sample with 3243 observations are obtained. All continuous variables are winsorized at the top and bottom one percent to mitigate the disturbance of outliers.

3.2. Variable definition and model construction

3.2.1. Vertical integration

The value added to sales (VAS) is widely used in the literature to measure corporate vertical integration degree. It is to use accounting data to calculate the share of a firm’s value added in the industrial chain in its sales revenue. The higher the share of value added is, the higher the degree of vertical integration is. Based on the original VAS proposed by Adelman (1955) and referring to the adjustment of the VAS in Buzzell (1983), and Fan and Peng (2017), we adopt the adjusted VAS (ADJVAS) to measure vertical integration. To ensure the validity of the index measurement, we refer to the method of Fan and Peng (2017) to eliminate the observations with ADJVAS deviating from the reasonable range [0, 1].

3.2.2. Cumulative abnormal return

We set January 20, 2020 when the National Health Commission of the People’s Republic of China declared the COVID-19 as a Class B infectious disease as the event day, and measure cumulative abnormal return of stocks by using the market model method. The basic model of the market model method is as follows:

\[ \text{Ret}_{it} = \alpha_0 + \alpha_1 \text{Ret}_{mt} + \epsilon \]  

(1)

In Model (1), \( \text{Ret}_{it} \) denotes the stock return of firm \( i \) on the trading day \( t \) (with the cash dividend reinvestment considered), and \( \text{Ret}_{mt} \) denotes the market return on the trading day \( t \), which is equal to the market return calculated by the weighted average market capitalization. A total of 200 trading days before the event day \([-210, -10]\) are set as the estimation period, and the risk-free return \( \alpha_0 \) of each stock and the correlation \( \alpha_1 \) between individual stock return and market return are estimated by Model (1). The abnormal return of each stock in each trading day near the event day is calculated by Model (2):

\[ \text{Abn}_\text{i,Ret}_{t} = \text{Ret}_{i,t} - \alpha_0 - \alpha_1 \text{Ret}_{mt} \]  

(2)

The cumulative abnormal return for nine trading days (three trading days before the event day and five trading days after the event day \([-3, +5]\)) is used to measure the stock market reaction \( \text{CAR} \). Finally, we build Model (3) to examine the impact of vertical integration on stock market reaction under the shock of the COVID-19 pandemic:

\[ \text{CAR}_i = \alpha_0 + \alpha_1 \text{ADJVAS}_i + \Sigma \text{Controls} + \Sigma \text{Industry} + \Sigma \text{Province} + \delta \]  

(3)

Model (3) adopts the OLS regression, in which the dependent variable \( \text{CAR} \) is the cumulative abnormal return of firm \( i \) in the event window \([-3, +5]\), and the independent variable \( \text{ADJVAS} \) is the vertical integration of firm \( i \) calculated by financial data in the end of 2018. Following prior researches, control variables include firm size (Size), asset-liability ratio (Lev), return on assets (ROA), ownership type (SOE), book-to-market ratio (BM), cash holding (Cash), \( \beta \) value of stocks (Beta), economic connection between the firm and Hubei
Province, where the COVID-19 pandemic initially outbroke (HB_Corr), board size (Board), shareholding of institutional investors (InstiShare) and equity concentration (Top1). In addition, we control the industry (Industry) and province-level (Province) fixed effects in Model (3). Table 1 reports the definition of main variables.

3.2.3. Descriptive statistics

Table 2 reports descriptive statistics of the main variables. The results show that the average (median) of CAR is −0.032 (−0.049), and the standard deviation of CAR is 0.120, which means that the cumulative abnormal return of stocks in the event window is negative on the whole after COVID-19 is declared person-to-person spread, indicating that the pandemic has a negative impact on the capital market in a short time. However, the market reaction to the shock of the pandemic is quite different among firms, which may be related to the firm heterogeneity. The mean (median) of ADJVAS is 0.477 (0.464) and its standard deviation is 0.213. The distribution of other control variables in terms of the mean, the median and the standard deviation is basically similar to that in previous literature.

4. Empirical results and analysis

4.1. Main results

Table 3 reports the impact of vertical integration on corporate value under the shock of the COVID-19 pandemic. Vertical integration (VAS) calculated by original VAS is the independent variable in columns (1) and (2), and vertical integration (ADJVAS) calculated by ADJVAS is the independent variable in columns (3) and (4). Columns (1) and (3) only control the industry and province-level fixed effects, while columns (2) and (4) include other control variables. The results show that coefficients of VAS and ADJVAS are significantly positive at the 1% level (t-stats are 5.79, 4.76, 2.92 and 4.03, respectively), indicating that the higher the vertical integration is, the higher the corporate value under the shock of the COVID-19 pandemic is. Based on the coefficient in column (4), an increase of one standard deviation of vertical integration leads the cumulative abnormal return to increase by about 0.07 standard deviations (≈0.040×0.213/0.120×100%). Overall, although under the uncertainty shock caused by the COVID-19 pandemic, vertical integration may not only inhibit external transaction costs and enhance corporate value, but also aggravate internal organization costs and reduce
corporate value, the results in Table 3 show that the former plays a dominant role, and thus vertical integration has a positive impact on corporate value under the uncertainty shock caused by the COVID-19 pandemic, which verifies H1a.

4.2. Robustness tests

4.2.1. Vertical integration and corporate value after resumption of work and production

The baseline test takes the initial outbreak period of the COVID-19 pandemic as the event window, and finds that the higher the vertical integration is, the higher the cumulative abnormal return in the event window is. If this relationship is due to the impact of uncertainty on the value of vertical integration, when the uncertainty declines, we should observe that the relationship between vertical integration and corporate value is opposite to that when the uncertainty rises. In other words, if the market favors vertically integrated firms when the external uncertainty rises sharply, when the uncertainty declines, the market valuation of vertically specialized firms will rise. In order to verify it, we take February 22, 2020 when the State Council of China issued the guidelines for the prevention and control of novel coronavirus pneumonia pandemic for work and production resumption in enterprises and public institutions6 as the event day of the decline of uncertainty, and examine whether the stock market reaction near the event day improves with the increase (decrease) of the vertical specialization level (vertical integration level). Specifically, the market model method is used to measure the abnormal return7 of each trading day near the event day, and the cumulative abnormal return is calculated correspondingly in the window period of resumption of work and production (Work_CAR); and the dependent variable CAR in Model (3) is replaced by Work_CAR. Considering that the sequent COVID-19 pandemic in other countries may affect firms with international business, we define a dummy variable Oversea. When a firm has its operating income from overseas in 2018, the value of Oversea is 1; otherwise, it is 0. Other variables are consistent with those in Model (3). The results are reported in Table 4. Columns (1) and (2) of Table 4 report regression results with the event windows of [-1, +1] and [-3, +3], respectively. The results show that ADJVAS in columns (1) and (2) are both significantly negative at least at the 10% level, indicating that the market believes that the notice on resumption of work and production is more significant positive news for firms with higher vertical specialization (lower vertical integration). Overall, the results in Table 4 show

| Dependent Variable: CAR [-3, +5] | (1) | (2) | (3) | (4) |
|---------------------------------|-----|-----|-----|-----|
| VAS/ADJVAS                      | 0.054*** | (5.79) | 0.046*** | (4.76) | 0.029*** | (2.92) | 0.040*** | (4.03) |
| Size                            | 0.017*** | (9.21) | -0.012 | (-0.78) | -0.002 | (-0.12) | 0.001 | (0.39) |
| Lev                             | 0.011*** | (5.47) | 0.044** | (2.18) | 0.012 | (0.77) | 0.030** | (2.28) |
| ROA                             | 0.011*** | (5.56) | 0.043** | (2.17) | -0.007 | (-0.04) | 0.002 | (0.44) |
| SOE                             | 0.001   | (0.39) | 0.002   | (0.44) | 0.001   | (0.06) | 0.001   | (0.06) |
| BM                              | 0.013*** | (5.47) | 0.044** | (2.18) | 0.012 | (0.77) | 0.030** | (2.28) |
| Cash                            | -0.044*** | (-2.95) | -0.043*** | (-2.90) | -0.007 | (-0.04) | 0.002 | (0.44) |
| Beta                            | 0.086*** | (8.04) | 0.086*** | (8.04) | -0.001 | (-0.02) | 0.001 | (0.06) |
| HB_Corr                         | 0.279*** | (7.59) | 0.280*** | (7.68) | -0.012 | (-1.11) | -0.012 | (-1.09) |
| Top1                            | -0.124*** | (-7.76) | -0.602*** | (-12.69) | -0.113*** | (-7.26) | -0.602*** | (-12.70) |
| Constant                        | -0.602*** | (-12.69) | -0.113*** | (-7.26) | -0.602*** | (-12.70) | -0.602*** | (-12.70) |
| Industry& Province              | Yes     | Yes     | Yes     | Yes     |
| N                               | 3243    | 3243    | 3243    | 3243    |
| Adj.R2                          | 0.074   | 0.146   | 0.067   | 0.145   |

Note: the t-statistics shown in parentheses are adjusted for clustering by province. *, ** and *** indicate significance at the levels of 10%, 5% and 1%, respectively (the same below).

6 http://www.gov.cn/zhengce/content/2020-02/22/content_5482025.htm.

7 In order to avoid the impact of the pandemic on stock prices, the selection of the estimation period here is consistent with that of the baseline test, that is, 200 trading days in the window period of [-210, -10] before January 20, 2020.
that when the uncertainty declines, the market valuation of vertically specialized firms increases, indicating that the positive impact of vertical integration on corporate value found in the baseline test is indeed due to the rise of uncertainty, which strengthens our conclusion. In addition, these results also mitigate the endogeneity issue that the positive relationship between vertical integration and corporate value during the pandemic is induced by unobservable firm-level characteristics. For example, firms with better corporate governance may have higher degree of vertical integration and higher stock performance during the pandemic. If the positive relationship we document is totally driven by a third firm-level variable, say, corporate governance, we should not observe that the vertical integration is negatively correlated with corporate value after the resumption of work and production. In other words, firms with better corporate governance are unlikely to have worse value after the resumption of work and production.

4.2.2. Vertical integration and firm performance

The baseline test uses the stock market performance to examine the impact of vertical integration on corporate value under the shock of uncertainty. If vertical integration can reduce external transaction costs and improve firm adaptability under the uncertainty shock, we expect that vertical integration will also have a positive impact on actual financial performance. In order to verify it, we use the data of the first quarterly reports and the half-year reports in 2020 to test the impact of vertical integration on actual financial performance. Specifically, we calculate the ROA according to the first quarterly reports and the half-year reports in 2020 to test the impact of vertical integration on actual financial performance. We then use Season1_ROA and HalfYr_ROA to replace the dependent variable Car in Model (3). Considering that the COVID-19 pandemic in other countries may have an impact on corporate performance, we use the data from 2007 to 2018 as the baseline sample, and control the year fixed effect, so as to observe the relationship between vertical integration and ROA in the first quarterly reports and the half-year reports in previous years. Note that we measure the degree of vertical integration at the firm-year level in this section. The regression results are reported in columns (3) and (4) of Table 5. The results show that in the baseline sample, when the dependent variable is Season1_ROA, the coefficient of ADJVAS is negative; when the dependent variable is HalfYr_ROA, the coefficient of ADJVAS is
positive but insignificant. The empirical evidence of previous years shows that there is no naturally positive correlation between vertical integration and the firm performance reflected in the first quarterly reports and the half-year reports. The results in Table 5 suggest that the positive impact of vertical integration on corporate value is not only reflected in the market performance, but also in the financial performance, which strengthens the main conclusion.

4.2.3. Other robustness tests
We also conduct other robustness tests, including changing the event windows by selecting \([-1, +1], [-2, +2], [-3, +3]\) and \([-3, +10]\) to measure the cumulative abnormal return of stocks under the shock of the COVID-19 pandemic; changing the estimation periods by selecting \([-C0, +C1], [-C2, +C0], [-C3, +C0], [-C3, +10]\) to recalculate the cumulative abnormal return of stocks; setting the alternative event day as the closure date of Wuhan; referring to Fan and Peng (2017) to adjust the calculation method of VAS; excluding listed firms that are registered in Hubei Province; and avoiding the influence of related party transactions. Unreported results show that the research conclusions remain unchanged.

5. Cross-sectional analyses
The impact of vertical integration on corporate value is determined by both external transaction costs and internal organization costs. Therefore, in this section we further study the heterogeneous impacts of vertical integration on corporate value among firms facing different external transaction costs and internal organization costs under the shock of uncertainty caused by the COVID-19 pandemic.

5.1. Impact of external transaction costs
Under the shock of the uncertainty caused by the COVID-19 pandemic, the increase in external transaction costs varies among different firms. If the increase in external transaction costs is higher, the role of vertical integration in reducing external transaction costs will be more prominent, thus having a more significantly positive effect on corporate value. Therefore, we study whether the impact of
vertical integration on corporate value is varied with external transaction costs from three perspectives: asset specificity, firm status and industry competition.

First, asset specificity. Asset specificity means that the value of specific-purpose investment will be greatly reduced once it is used for other purposes (Williamson, 1979). Once a firm with high asset specificity encounters the break of external supply chain, it will face high idle costs of specific assets, which means it is more likely that such firm suffers the hold-up by counterparties under the shock of uncertainty caused by the COVID-19 pandemic. In other words, under the shock of uncertainty, the increase in external transaction costs is greater in firms with high asset specificity, so we predict that the positive impact of vertical integration on the value of such firms is more significant. To verify it, we use two methods to measure asset specificity. (1) Referring to Balakrishnan and Fox (1993) and Mocnik (2001), we use the ratio of the sum of R&D expenses and advertising expenses to sales revenue to measure asset specificity. The higher the ratio is, the higher the asset specificity is. (2) We use the exit value equation in Berger et al. (1996) to measure asset specificity. The higher the exit value of assets is, the lower the asset specificity is. Furthermore, according to the median of asset specificity, the full sample is divided into two sub-samples, namely, $H_{SP1}$ and $L_{SP1}$, as well as $H_{SP2}$ and $L_{SP2}$. We re-estimate Model (3) in four sub-samples, and the results are shown in Table 6. In the sub-sample of $H_{SP1}$, the coefficient of $ADJVAS$ is 0.065, which is significant at the 1% level, while in the sub-sample of $L_{SP1}$, the coefficient of $ADJVAS$ is insignificant. The seemingly unrelated estimation (SUE) method is used to test the coefficient difference, and the results show that the difference in coefficients of the two sub-samples is significant at the 1% level indicating that the positive effect of vertical integration on corporate value under the shock of the COVID-19 pandemic is more pronounced in firms with high asset specificity. Similarly, the coefficient of $ADJVAS$ in the sub-sample of $H_{SP2}$ is more significant than that in the sub-sample of $L_{SP2}$. The above results show that when the asset specificity is higher, the probability that a firm faces hold-up by counterparties during the pandemic is higher; that is, the increase of external transaction costs is higher, and thus vertical integration has a more significantly positive effect on corporate value.

Second, firm status. The higher the firm status in an industry is, the stronger its importance to upstream and downstream firms is, and the higher its bargaining power in the supply chain is (Porter, 1980). During the COVID-19 pandemic, in order to maintain the long-term transaction relationship, the counterparties are more likely to guarantee the raw material supply and product sales to high-status firms,

8 Exit value equation: $Exit = 1.0*Cash + 0.715*Rec + 0.547*Inv + 0.535*PPE$, where $Exit$ denotes the exit value of assets, $Cash$ the cash and marketable securities, $Rec$ the accounts receivable, $Inv$ the inventory, and $PPE$ the fixed assets.
with a smaller possibility of hold-up (Klein and Leffler, 1981; Fan et al., 2017). Therefore, under the shock of uncertainty caused by the COVID-19 pandemic, the rise in external transaction costs of low-status firms is more significant than that of high-status firms, and the advantages of low-status firms with high vertical integration in avoiding external transaction costs are prominent. Therefore, we expect that under the shock of the uncertainty caused by the COVID-19 pandemic, the positive effect of vertical integration on the value of low-status firms is more significant. In order to verify it, we measure firm status by firm size and market share. Firm size is measured by the total assets, and market share is measured by the proportion of firms’ sales revenue in the total sales revenue in the industry. The full sample is divided into sub-samples of $H_{\text{Size}}$ and $L_{\text{Size}}$, as well as $H_{\text{MShare}}$ and $L_{\text{MShare}}$ according to the median of firm size and market share. Model (3) is re-estimated in the four sub-samples, and the results are shown in Table 7. In $L_{\text{Size}}$, the coefficient of $ADJVAS$ is 0.062, which is significant at the 1% level, while in the sub-sample of $H_{\text{Size}}$, the coefficient of $ADJVAS$ is insignificant. There is a significant difference between the two sub-samples at the 10% level. Similarly, the coefficient of $ADJVAS$ in the sub-sample of $L_{\text{MShare}}$ is more significant than that in $H_{\text{MShare}}$. The results in Table 7 show that the lower the firm status is, the more likely it is to suffer from the external supply chain disruption during the pandemic; that is, the rise in external transaction costs is more significant, and thus the positive effect of vertical integration on corporate value is more significant.

Third, industry competition. Previous studies show that industry competition affects the range of transaction partners of firms, and thus influences the uncertainty of existing supply chain cooperation (Acemoglu et al., 2010). When the industry competition for the focal firm is fierce, it means that even if its upstream and downstream firms cut off the cooperative relationship with the focal firm, it is very likely for those firms to find new partners in the same industry. Therefore, when the industry competition is high, it is more likely that the focal firm faces hold-up by external counterparties during the pandemic. In other words, under the shock of uncertainty caused by the COVID-19 pandemic, the rise in external transaction costs for such firms is more significant. Therefore, we expect that when the industry competition is high, the positive effect of vertical integration on corporate value is more significant. In order to verify it, we measure the industry competition by the Herfindahl-Hirschman Index of the industry, and divide the full sample into sub-samples of $H_{\text{Compete}}$ and $L_{\text{Compete}}$ according to the median of industry competition. We re-estimate Model (3) in the two sub-samples, and the results are reported in columns (1) and (2) of Table 8. In the sub-sample of $H_{\text{Compete}}$, the coefficient of $ADJVAS$ is 0.058, which is significant at the 1% level, while in the sub-sample of $L_{\text{Compete}}$, the coefficient of $ADJVAS$ is insignificant. It indicates that when the industry competition is high, the positive effect of vertical integration on corporate value is more significant, which is consistent with the expectation and strengthens the main conclusion.
5.2. Impact of internal organization costs

As mentioned above, vertical integration generates significant internal organization costs when reducing transaction costs. Insider tunneling is an important source of internal organization costs (Fan et al., 2017). In crises such as the COVID-19 pandemic, the motivation and ability of insider tunneling are enhanced, which leads to higher internal organization costs. Under the shock of the uncertainty caused by the pandemic, the rise in internal organization costs varies among different types of firms. If there is a slight rise in internal organization costs, the advantage of vertical integration in reducing external transaction costs will be more prominent, so the positive effect of vertical integration on corporate value is more significant. Good corporate governance is conducive to strengthening the restriction and incentive for insiders, thus restraining insider tunneling and reducing internal organization costs. Therefore, we expect that under the shock of uncertainty caused by the COVID-19 pandemic, the higher the level of corporate governance is, the lower the increase of internal organization costs is, and the more significant the positive impact of vertical integration on corporate value is.

Specifically, we measure corporate governance from three dimensions: the proportion of independent directors, the shareholding ratio of management and the degree of ownership balance (Jensen and Meckling, 1976; Klein, 2002). The full sample is divided into sub-samples of $H_{Indir}$ and $L_{Indir}$, sub-samples of $H_{MHold}$ and $L_{MHold}$, as well as sub-samples of $H_{Balance}$ and $L_{Balance}$ according to the median of the above three indicators. Model (3) is re-estimated in the six sub-samples, and the results are shown in Table 9. Columns (1) and (2) show that in the sub-sample of $H_{Indir}$, the coefficient of ADJVAS is 0.058, and is significant at the 1% level, while in $L_{Indir}$, the coefficient of ADJVAS is 0.005, with a lower significance level. Column (3) and (4) show that the coefficient of ADJVAS in $H_{MHold}$ is more significant than that in $L_{MHold}$. Likewise, columns (5) and (6) show that the coefficient of ADJVAS in $H_{Balance}$ is more significant than that in $L_{Balance}$. The results in Table 9 show that when the level of corporate governance is sound, the rise in internal organization costs under the uncertainty shock caused by the COVID-19 pandemic is lower, and the disadvantage of vertical integration in increasing internal organization costs is less significant, so the positive effect of vertical integration on corporate value is more pronounced, which is consistent with the above expectation and further supports the main conclusion.
Table 9
Impact of corporate governance.

|            | (1)          | (2)          | (3)          | (4)          | (5)          | (6)          |
|------------|--------------|--------------|--------------|--------------|--------------|--------------|
| CAR[-3, +5]| H_Indir      | L_Indir      | H_MHold      | L_MHold      | H_Balance    | L_Balance    |
| ADJVAS     | 0.058***     | 0.022        | 0.059***     | 0.027*       | 0.062***     | 0.025*       |
| (3.67)     | (1.53)       | (3.47)       | (1.93)       | (4.01)       | (1.78)       |
| Size       | 0.019***     | 0.017***     | 0.031***     | 0.009***     | 0.021***     | 0.016***     |
| (5.37)     | (5.43)       | (7.53)       | (2.90)       | (6.27)       | (4.63)       |
| Lev        | 0.020        | −0.041**     | 0.005        | −0.002       | −0.019       | −0.023       |
| (1.02)     | (−2.20)      | (0.21)       | (1.38)       | (−0.06)      | (−1.13)      |
| ROA        | 0.037        | 0.016        | 0.046        | 0.005        | 0.053**      | −0.003       |
| (1.38)     | (0.51)       | (1.60)       | (0.14)       | (2.05)       | (−0.09)      |
| SOE        | −0.008       | 0.008        | −0.007       | 0.007        | 0.003        | −0.002       |
| (−0.94)    | (1.18)       | (−0.45)      | (1.05)       | (0.40)       | (−0.30)      |
| BM         | 0.011***     | 0.011***     | 0.019***     | 0.002        | 0.014***     | 0.009***     |
| (3.51)     | (3.59)       | (5.69)       | (0.58)       | (4.42)       | (2.66)       |
| Cash       | 0.048        | 0.048        | 0.046        | 0.042        | 0.007        | 0.072**      |
| (1.56)     | (1.55)       | (1.39)       | (1.46)       | (0.22)       | (2.40)       |
| Beta       | 0.092***     | 0.076***     | 0.104***     | 0.065***     | 0.087***     | 0.083***     |
| (8.02)     | (6.95)       | (8.52)       | (6.10)       | (7.75)       | (7.47)       |
| HB_Corr    | −0.003       | −0.081*      | −0.143***    | 0.020        | −0.050       | −0.024       |
| (−0.06)    | (−1.77)      | (−2.66)      | (0.48)       | (−1.05)      | (−0.51)      |
| Board      | 0.000        | −0.023       | −0.006       | 0.008        | −0.014       | 0.017        |
| (0.02)     | (−0.91)      | (−0.35)      | (0.49)       | (−0.83)      | (1.04)       |
| InstitShare| 0.274***     | 0.284***     | 0.188***     | 0.328***     | 0.263***     | 0.286***     |
| (4.28)     | (4.27)       | (2.92)       | (4.61)       | (4.42)       | (3.88)       |
| Top1       | 0.004        | −0.025       | −0.001       | −0.011       | −0.013       | −0.041*      |
| (0.21)     | (−1.19)      | (−0.03)      | (−0.54)      | (−0.36)      | (−1.75)      |
| Constant   | −0.635***    | −0.533***    | −0.924***    | −0.397***    | −0.634***    | −0.596***    |
| (−7.52)    | (−5.93)      | (−9.07)      | (−5.26)      | (−7.48)      | (−7.38)      |
| Industry & Province | Yes | Yes | Yes | Yes | Yes | Yes |
| N          | 1518         | 1725         | 1573         | 1573         | 1621         | 1622         |
| Adj. R²    | 0.148        | 0.136        | 0.169        | 0.142        | 0.149        | 0.134        |
| Chi²       | 8.019***     | 4.758**      | 2.914*       |              |              |              |
| p-value    | (0.005)      | (0.029)      | (0.088)      |              |              |              |

6. Conclusions

The boundary of firms has been the focus of new institutional economics. According to transaction-cost economics, firm and market are two alternative transaction governance structures, and transaction cost is the key determinant of these two structures, of which uncertainty is the important source. Under the shock of the COVID-19 pandemic, this paper examines whether vertical integration can create value for firms when the uncertainty increased. Specifically, the event study method is used to analyze the impact of vertical integration on cumulative abnormal return during the pandemic window period. We found that vertical integration had a positive impact on cumulative abnormal return during the pandemic window period. When external transaction costs are higher or internal organization costs are lower under the uncertainty shock caused by the COVID-19 pandemic, the positive impact of vertical integration on cumulative abnormal return is more pronounced. Our results indicate that vertical integration could avoid uncertainty, reduce transaction costs, and improve corporate value with the increase in uncertainty caused by sudden crises. In addition, the conclusion reflects that uncertainty is an important factor affecting vertical integration, providing empirical evidence for the main theory in transaction-cost economics.

This paper has the following policy implications. First, The experience of the COVID-19 pandemic shows that although China has taken measures to effectively control the COVID-19 pandemic and push forward the resumption of work and production, if it relies too much on international circulation, the deterioration of the COVID-19 pandemic in other countries is likely to cause a secondary shock on China’s industrial chain. As vertical integration can avoid external uncertainty and thus improve corporate value, improving domestic industrial chain and smoothing domestic circulation are of great significance to build independent and controllable industrial chains in China and prevent and deal with the shock of global sudden uncertainties such as the COVID-19 pandemic. Second, it is necessary to improve corporate governance and enhance economic efficiency. Compared with the market, while the enterprise can improve adaptability and avoid external transaction costs under the shock of uncertainty, it also have to face internal organization costs, which have adverse effects on economic efficiency. High-level corporate governance can reduce the efficiency loss and enhance firms’ advantages in adapting to uncertainty and avoiding transaction costs. Therefore, it is necessary to establish and improve the supervision system and explore an efficient corporate governance model to improve the economic efficiency of firms.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
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