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Does real flexibility help firms navigate the COVID-19 pandemic?

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\textbf{ABSTRACT}

Building on the investment-based asset pricing framework, we show that firms’ ability to timely scale down their operations reduces the sensitivity of their equity value to large adverse productivity shocks. Using U.S. data in the times of the COVID-19 pandemic, we provide empirical evidence consistent with our model’s predictions. Real flexibility curbs losses in firm value and reduces return volatility, especially for firms with high book-to-market or high COVID-19 exposure, consistent with the idea that the benefits of real flexibility are associated primarily with contraction options during the COVID-19 crisis. Our analysis shows that real flexibility provides incremental and complementary protection beyond financial flexibility. Besides its impact on stock prices, real flexibility also helps firms sustain earnings during 2020, compared with 2019 when the pandemic had not struck. Our work demonstrates that real flexibility is an important tool for corporate managers in navigating episodes of disasters.

1. Introduction

The COVID-19 pandemic has triggered the worst economic crisis since the Great Depression in its suddenness and severity (Baldwin and Weder di Mauro 2020; Gopinath, 2020; IMF, 2020). The stock markets reacted with unprecedented crashes, reflecting the fear and uncertainties caused by the serious disruption to all business activities (Baker et al., 2020).\footnote{For example, the S&P index lost more than a third of its value in the short period of time during February and March 2020. As a comparison, it took one year for S&P 500 to decline by the same magnitude during the 2008 Financial Crisis (Capelle-Blancard & Desroziers, 2020).} In this context, firms’ ability to timely scale down their operations, which reduces the amount of unproductive capital, should ease investors’ fears and provide a cushion for firm value. It is, therefore, logical and important to ask whether and how firms’ real flexibility affects their performance during the COVID-19 crisis.\footnote{We use the term \textit{real flexibility} to denote the ease at which firms can exercise their \textit{real options} in making adjustments on the scale of their operations, in the presence of uncertainty. It may also be termed as, for example, scale flexibility, investment flexibility, operating flexibility, etc.}

Despite the growing interest in real options, the theoretical and empirical work on the role played by real flexibility in the context of the recent pandemic remain scarce.\footnote{For recent real options studies, see, e.g., Cooper (2006), Dalziel (2009), Grullon et al. (2012), Hackbarth and Johnson (2015), Herhausen et al. (2021).} On the other hand, the role of financial flexibility is well documented (see, e.g., Fahlenbrach et al., 2020; He & Ren, 2022). Although real flexibility and financial flexibility capture different aspects of a firm’s business activities, they are nevertheless nontrivially associated (Gu et al., 2017; MacKay, 2003; Reinartz & Schmid, 2016). Do their effects coexist in the...
COVID-19 crisis? What are the relative magnitudes of economic significance? How do they interact or complement each other? Consequently, a side-by-side investigation of the two dimensions of corporate flexibility must be carefully carried out in order to have a more complete understanding of their respective importance in the recent pandemic.

In this paper, we answer the above questions by evaluating the benefits of real flexibility during the early stages of the COVID-19 outbreak. We employ the neoclassical investment model of Hackbarth and Johnson (2015, the HJ model hereafter) as our theoretical framework, where firms have real options to contract and expand their business in response to changes in their productivity levels. Hackbarth and Johnson (2015) show that a firm can derive sizeable value from the contraction (expansion) options when its productivity is low (high). The added value from real options also depends on the adjustment costs associated with exercising those options. A high (low) adjustment cost implies low (high) flexibility; therefore, the model provides a natural setting for investigating how real flexibility affects firm value during the economic downturn triggered by the COVID-19 shock.

We show that the sensitivity of firm value to productivity shocks (value-productivity sensitivity), derived from the HJ model, is positively correlated to the contraction adjustment costs. We focus on the contraction adjustment costs because these are particularly relevant during the economic crisis, as a typical firm is more likely to scale down their operations rather than to scale up. The model predicts that flexible firms are less adversely impacted by the economic downturn brought about by the pandemic. Furthermore, the impact of real flexibility on the value-productivity sensitivity is more pronounced for firms with lower productivity, which are more likely to exercise their contraction options. Our empirical tests support these theoretical predictions.

We employ a sample of U.S. non-financial firms and show that firms with higher real flexibility have less negative cumulative returns during the stock market crashes between February 3rd and March 23rd, 2020. Therefore, contraction options provide a cushion against productivity shocks during the economic downturn, and thereby protect firms’ value. Our results are robust to controlling for financial flexibility, which is previously found to reduce the impact of the pandemic on stock prices (Fahlenbrach et al., 2020). Our regression estimates also reveal that the economic magnitudes of the real-flexibility effect is comparable to financial flexibility. Therefore, real flexibility proves to be a different dimension beyond financial flexibility and provides incremental resilience that is valuable to investors for their portfolio risk management. In addition, real flexibility becomes more important for firms with lower financial flexibility, and thus offers complementary protection beyond financial flexibility. Interestingly, we also find that the benefit of financial flexibility is more pronounced for firms with higher real flexibility — this implies that real flexibility facilitates a “multiplier effect” for financial flexibility.

Furthermore, we find evidence that the value of real flexibility is more pronounced for firms with a higher book-to-market ratio or more COVID-19 exposure, consistent with the idea that the benefits of flexibility are associated primarily with contraction options, rather than expansion options, during the COVID-19 crisis. In addition, real flexibility reduces return volatility, demonstrating another aspect of its benefits in providing value resilience. Aside from the stock market performance, we also analyze the impact of real flexibility on corporate earnings and find that the quarterly return-on-asset is positively associated with real flexibility during 2019 and 2020. Importantly, this association is more pronounced during 2020 when the pandemic struck. Taken together, our results support the notion that real flexibility adds value during the COVID-19 economic downturn.

To the best of our knowledge, the most closely related empirical work to ours is Liu et al. (2021), who study the effect of operating flexibility on stock returns during the COVID-19 outbreak. However, our work differs from theirs in a few important ways. First, unlike their Chinese setting, our study is based on the U.S. sample and compares more directly with the mainstream literature of COVID-19 studies (see, e.g., Albuquerque et al., 2020; Pagano et al., 2020). For example, they employ the lockdown of Wuhan city in China as the shock event and use the population flow from Wuhan to other provinces to measure the degree of infection. These research methods are only applicable to China’s unique situation, not to mention China’s macroeconomic, social and political environments which are distinctively different from other economies (Allen et al., 2005; Liu et al., 2019). On the other hand, our empirical methodology is generic and can be directly adapted to study other countries. Second, we provide a wider range of empirical tests. These include tests examining the interplay between the real-flexibility and financial-flexibility effects, cross-sectional tests conditional on profitability and firm-level COVID-19 exposure, return volatility tests, and tests on corporate earnings. We also include a larger set of controls which are potentially correlated to both real flexibility and stock returns. The omission of these controls can raise biasedness concerns about the regression estimates. In addition, we employ instrumental-variables estimations and the propensity score matching (PSM) method to mitigate potential endogeneity concerns. Third, in contrast to their purely empirical approach, we build our work upon an explicit real-options model, derive closed-form expressions of a firm’s value sensitivity to profitability shocks and obtain testable hypotheses accordingly. We believe this approach offers a rigorous and insightful inquiry into the mechanism of real options behind the observed effects of real flexibility.

Our work contributes to the literature on corporate resilience to the COVID-19 induced economic crisis. Albuquerque et al. (2020)

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4 The HJ model does not distinguish between productivity and profitability. Shocks to productivity or profitability may come from either the supply side or the demand side. In the case of the COVID-19 crisis, the shock may be viewed as a sudden revenue plummet due to government lockdown and social distancing policies.

5 Our choice of the sample period February 3rd and March 23rd, 2020 follows closely that of Fahlenbrach et al. (2020). Although the COVID-19 cases rose significantly only later in the year, the initial cases in mid-February had already triggered market crashes until March 24th, when the Federal Open Market Committee announced its financial aid package. On the other hand, after March 24th, the U.S. stock market was on a relatively steady trajectory of rebounding. It is the firms’ corporate earnings that continued to show negative reactions in the latter part of the year. See Fig. 5 for an illustration. Empirical studies using the early 2020’s stock returns in the U.S. sample as the dependent variable are a common practice, see also, e.g., Albuquerque et al. (2020), Pagano et al. (2020), Sinagl (2020) and Davison (2020).
find that stocks with higher environmental and social ratings have significantly higher returns, lower return volatility, and higher operating profit margins during the first quarter of 2020. Baker et al. (2020) conclude that government restrictions and social distancing are the main reasons behind the dramatic U.S. stock market reactions. Hassan et al. (2020) and Li et al. (2020) construct firm-level measures of exposure to the pandemic using transcripts of earnings conference calls and demonstrate that stocks less exposed to the pandemic are less adversely impacted. Tosun et al. (2021) argue that corporate exposure to prior disasters can assist in firm-level measures of exposure to the pandemic using transcripts of earnings conference calls and demonstrate that stocks less operating profit margins during the first quarter of 2020. Baker et al. (2020) conclude that government restrictions and social flexibility affects corporate performance in the presence of large negative productivity shocks. Financial flexibility proves to have a significant and positive impact on enterprise performance (Davidson, 2020; Fahlenbrach et al., 2020; Teng et al., 2021; Yasir & Alabassi, 2020). Corporate governance and culture also make a difference in firms’ performances (Ding et al., 2021; Khatib & Nour, 2021; Li et al., 2020; Mertzanis, 2021). In addition, our findings show that the flexibility associated with real options provides firms with more resilience during the pandemic.

Secondly, our work contributes to the growing literature of real options, flexibility and firm value. Early investment models suggest that real-option exercise-costs affect firms’ investment policies (see, e.g., Hayashi, 1982; Abel & Eberly, 1993 and 1996; Dixit et al., 1994). High levels of uncertainty reduce investments but raise the value of the real options associated with the investments (Kandel & Pearson, 2002; Metcalf & Hassett, 1995; Sarkar, 2000). Despite the flexibility benefits offered by real options, a trade-off between flexibility and commitment exists (Herhausen et al., 2021; Li & Li, 2010). For example, Daiziel (2009) show that large firms opt to forgo flexibility in favor of relationship-fostering commitments when investing in small firm equity alliances in the presence of high rivalry, despite a high uncertainty environment. More recently, several theoretical works demonstrate that investment flexibility affects firms’ risk and return profiles (Cooper, 2006; Guthrie, 2011; Ozdagli, 2012). Hackbarth and Johnson (2015) and Gu et al. (2018) provide theoretical ground and empirical evidence that expansion- and contraction-options can counter the effect of operating leverage on risk premium. Gu et al. (2017) find that inflexible firms adopt a lower level of financial leverage. Del Viva et al. (2017) document that firms with growth options exhibit more positively skewed returns. Our work differs from them and examines how real flexibility affects corporate performance in the presence of large negative productivity shocks.

The rest of this paper is organized as follows. Section 2 discusses our hypotheses motivated from the HJ model. Section 3 introduces the sample and measures used in the empirical tests. Section 4 and Section 5 report our empirical results. Section 6 concludes our findings.

2. Hypothesis development

2.1. Model framework

We study the firm value’s response to productivity shocks caused by COVID-19 using the real options model developed by Hackbarth and Johnson (2015). We choose the HJ model mainly because of its analytical tractability and elegance.\(^6\)

The HJ model considers a firm whose profit flow rate is \(\Pi_t = \theta_t^{1+\gamma}K_t - mK_t\), where \(K\) denotes the capital assets, and \(\theta\) is the productivity level. \(\gamma \in (0, 1)\) captures the decreasing return to scale, and \(m > 0\) measures operating cost per unit capital asset. The firm productivity \(\theta\) evolves exogenously according to a diffusion process, and in response, the firm chooses its optimal scale of operations \(K_t\) to maximize the firm value \(J\), the discounted value of the above profit stream, subject to scale-adjustment costs.

If the firm can choose \(K_t\) freely without incurring any costs, then the firm will always set \(K_t\) to its target value \(K_t^* = (m/\gamma)^{(1/(1-\gamma))}\theta_t\) to maximize its profit flow. However, when capital adjustment incurs lump-sum costs, a small deviation of \(K_t\) from \(K_t^*\) would not justify its adjustment, therefore the firm’s optimal strategy is to wait for \(\theta\) to evolve until the benefit of capital adjustment outweighs the cost. Hence the firm’s optimal policy for \(K_t\) is an infrequent discrete adjustment. Assuming a convenient form of adjustment-cost structure, Hackbarth and Johnson (2015) show that a single state variable \(Z_t = K_t/\theta_t\) is sufficient to summarize the firm’s investment policy. See Fig. 1 for an illustration of the optimal policy. The state-variable \(Z_t\) evolves within the interval \([L, U]\). Upon contacting the boundaries, adjustment on \(K_t\) occurs and \(Z_t\) jumps to target levels at \(G\) and \(H\), respectively. These four parameters, \(L, G, H\) and \(U\), are determined by a set of optimality conditions for the firm’s value-maximization problem, as detailed in Hackbarth and Johnson (2015).

2.2. The sensitivity of firm value to productivity shocks

We consider how productivity shocks affect firm value under the HJ model. To do so, we examine the elasticity, denoted by \(\varepsilon\), of firm value \(J\) with respect to productivity \(\theta\), i.e.,

\[
\varepsilon = \frac{\theta \partial J}{J \partial \theta}.
\]

\(\varepsilon\) measures the percentage change of firm value in response to one percentage change of productivity. We first establish that \(\varepsilon\) derives contributions from the real options. For the convenience of discussion, we state the following proposition in terms of the scaled

\(^6\) For related classical investment models, see, e.g., Hayashi (1982), Abel and Blanchard (1986), Hayashi and Inoue (1990), Dixit et al. (1994) and Abel and Eberly (1993 and 1996).
The productivity $P_t = \theta_t / K_t$ instead of its reciprocal $Z_t$.

**Proposition.** The firm value elasticity with respect to productivity shocks, $\varepsilon$, can be decomposed as $\varepsilon(P) = \varepsilon_{\text{AIP}}(P) + \varepsilon_{\text{EO}}(P) + \varepsilon_{\text{CO}}(P)$, where the components denote contributions from the assets-in-place (AIP), expansion option (EO), and contraction option (CO), respectively. Moreover, the signs and monotonicity of the components are

$$\varepsilon_{\text{AIP}}(P) > 0, \quad \varepsilon_{\text{EO}}(P) > 0, \quad \varepsilon_{\text{CO}}(P) < 0,$$

where $\varepsilon'_{\text{AIP}}(P) = \frac{d\varepsilon_{\text{AIP}}(P)}{dP}$, etc.

In line with economic intuition, the assets in place induce a positive price-productivity sensitivity which is amplified when productivity is low, due to operating leverage effects – i.e., low productivity pushes up operating leverage and thereby makes prices more sensitive to the revenue fluctuations. During episodes of high productivity, the firm derives value from its expansion option, which enhances its incremental value gain per unit productivity growth. Therefore, the expansion option contributes positively to value-productivity sensitivity, and this contribution increases as productivity increases and approaches the expansion-option exercising threshold. On the other hand, during times of low productivity, the firm derives value from its contraction option, which curtails its loss from the productivity decline, resulting in a lower value loss per unit productivity decline. Therefore, the contraction option reduces value-productivity sensitivity, and this reduction effect is stronger as productivity decreases and approaches the contraction-option exercising threshold.

The contributions of the three components result in a sine-shaped $\varepsilon(P)$. Fig. 2 shows the three components of the firm value elasticity and how they interact to form this sine-shaped relation. In short, the expansion option enhances value sensitivity in times of high productivity in hope of higher firm value gain, whereas the contraction option damps this sensitivity during times of low productivity, and thereby provides a source of resilience against adverse productivity shocks.

### 2.3. Testable hypotheses

A firm’s expansion frictions are likely correlated to its contraction frictions, which produce opposite effects on firm’s value-productivity sensitivity. This means that it can be empirically challenging to observe the overall impact of real flexibility, because it is not straightforward to find a real flexibility measure that distinguishes between the two types of frictions. However, during a major negative economic shock such as the one triggered by the COVID-19 crisis, an average firm is less likely to be near their expansion thresholds. In such scenarios, firms’ real flexibility should be mainly exhibited through their contraction options. Our proposition...
(\text{FCO} < 0) affirms that contraction options reduce firm value’s sensitivity to productivity shocks, leading to a less-negative impact on firm value from a productivity decline. In contrast, firms that are more difficult to adjust their scales downwards should face higher value losses.

**Hypothesis 1.** Firms with higher real flexibility experience less value loss during the economic downturn.

To illustrate, Fig. 3 shows how the variable-cost parameter for contraction adjustments ($p_U$) affects the firm value-productivity sensitivity, with other parameters fixed at the baseline calibration values provided by Hackbarth and Johnson (2015). The parameter $p_U$ measures the amount of cash received by selling one unit of capital assets when exercising the contraction option. A lower value of $p_U$ corresponds to higher adjustment frictions due to higher loss during the “distress sale”, and hence reduces real flexibility. The figure demonstrates that flexible firms have lower levels of value sensitivity to productivity shocks. For example, conditional on $\log P = -10$, after a 10% drop in productivity, the firm with $p_U = 0.01$ experiences about 6% value loss, whereas the firm with $p_U = 0.25$ only loses about 3% of its value.

Furthermore, our proposition gives additional insight on the conditional pattern of the impact of real flexibility. Specifically, $i_{CO}^U(P) > 0$ implies that the contraction option reduces firm value sensitivity more when firm is closer to its contraction option exercising threshold. Therefore, the resilience provided by real flexibility is stronger for those firms. This is also demonstrated by Fig. 3, where the firm value-productivity sensitivity spread is broader when $\log P$ is lower.

**Hypothesis 2.** The value benefit of real flexibility during the economic downturn is higher for firms that are closer to exercising their contraction options.

### 3. Data and measures

Our sample includes the U.S. public firms with financial fundamentals available from the Compustat Fundamentals annual dataset in 2019. We focus on non-financial firms that are traded on NYSE, AMEX, and NASDAQ, and exclude utility, not-for-profit and governmental firms, which are heavily regulated by the state. We obtain daily stock returns from Compustat North America Security Daily and keep primary issues and common stocks of each firm. We further exclude firms with missing stock price data, and low-priced stocks for which the 2019 average share price is below $1.

Following Fahlenbrach et al. (2020), our main response variable is the collapse period return ($\text{ret}_\text{collapse}$), defined as the cumulative daily excess returns between February 3rd 2020 and March 23rd 2020, when the stock market experienced sharp decline. The daily excess return is calculated as the firm’s stock return in excess of the risk-free rate, proxied by the one-month daily treasury bill rate obtained from the St. Louis Federal Reserve. We report the summary statistics of the variables in our sample in Table 1. Here, the mean of $\text{ret}_\text{collapse}$ is $-37.52\%$, reflecting the magnitude of the stock market crash during February and March 2020. This is comparable to the corresponding value of $-37.8\%$ in Fahlenbrach et al. (2020).

Our measure for real flexibility follows Gu et al. (2018), which relates to the range of the inaction region $[L, U]$. According to the HJ model, the wider the inaction region is, the more reluctant the firm is to adjust its capital assets $K_t$ despite its being further away from the desired level $K_t^*$, reflecting the firm’s inflexibility. Gu et al. (2018) defines INFLEX as the firm’s historical range of quarterly operating costs over sales scaled by the volatility of quarterly sales over assets growth rates. We obtain the quarterly figures of operating costs, sales, and total assets from the Compustat Fundamentals quarterly dataset. We define real flexibility as $\text{FLEX} = 1 / \text{INFLEX}$, and takes its value at the last calendar quarter of 2019. Table 1 shows that FLEX has a large variation in our sample, with an interquartile range of 1.10, comparable with its mean value of 1.27. In untabulated ANOVA analysis results, we find that about 19% of the variation is accounted for by industry. This means that there remains 81%, i.e., a large proportion, of within-industry variation. Therefore, our measure is superior to other industry-level measures of various aspects of firms’ operating flexibility, e.g., Syverson’s (2004) inflexible employment, Balasubramanian and Sivadasan’s (2009) capital resaleability index and Kim’s (2018) wage premium. Such a firm-level measure allows us to examine real flexibility’s association with the firms’ performance beyond mere industry characteristics.

Our control variables include firm characteristics that are known to predict stock returns in the asset pricing literature, i.e., firms’ equity beta, book-to-market ratio, size, momentum, and profitability (see, e.g., Fama & French, 1993; Carhart, 1997; Novy-Marx, 2013). We also include a set of other firm characteristics that we will discuss in more detail alongside our empirical tests. For our tests examining the interplay between real flexibility and financial flexibility, we follow Fahlenbrach et al. (2020) and consider firms with high cash holdings, low short-term debt or low long-term debt as more financially flexible. A detailed definition of all our variables is given in Table B5. The distributions of our variables are broadly in line with Fahlenbrach et al. (2020).

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Gu et al. (2018) provide tests to demonstrate that the inflexibility measure INFLEX is significantly correlated to these industry-level inflexibility proxies. They also show that INFLEX is negatively related to the firm-level investment flexibility measures, including Eiseeldt and Rampini’s (2006) capital reallocation rate and Kim and Kung’s (2017) redeployability index. These results support the role of INFLEX in capturing various forms of frictions associated with adjusting physical and labour capital assets in the firm’s production activities. Consequently, the real flexibility measure FLEX, as motivated by the HJ model, captures and is synonymous to, e.g., scale flexibility, operational flexibility, investment flexibility and production flexibility.
Our conditioning variables for testing Hypothesis 2 measure the firm’s propensity to exercise its contraction option. The HJ model implies a monotonous relation between productivity and the book-to-market ratio. Therefore, our first choice is the book-to-market value. From another perspective, firms with high book-to-market ratio are usually equipped with more unproductive capital during economic downturns and are thus more in need of exercising their contraction options. The second conditioning variable is individual firms’ exposure to COVID-19, taken from Hassan et al. (2020)’s online repository. These exposure measures are computed as the proportion of words mentioning the pandemic-related vocabulary in firms’ earnings call transcripts. Firms with more pandemic exposure are more likely to need to exercise contraction options in response to shocks.

The sample consists of the U.S. public firms with financial fundamentals available from the Compustat Fundamentals annual dataset in 2019, for common stocks listed on NYSE, AMEX, or NASDAQ from the non-financial industry. Our main dependent variable is the collapse period return \( r_{\text{collapse}} \), defined as the cumulative of daily excess returns between February 3rd, 2020 and March 23rd, 2020. The main independent variable is FLEX, a measure of real flexibility. The rest are control and conditioning variables, other dependent variables. See Table B5 for more details about the definition of these variables.

Our conditioning variables for testing Hypothesis 2 measure the firm’s propensity to exercise its contraction option. The HJ model implies a monotonous relation between productivity and the book-to-market ratio. Therefore, our first choice is the book-to-market value. From another perspective, firms with high book-to-market ratio are usually equipped with more unproductive capital during economic downturns and are thus more in need of exercising their contraction options. The second conditioning variable is individual firms’ exposure to COVID-19, taken from Hassan et al. (2020)’s online repository. These exposure measures are computed as the proportion of words mentioning the pandemic-related vocabulary in firms’ earnings call transcripts. Firms with more pandemic exposure are more likely to need to exercise contraction options in response to shocks.

### Table 1
Summary statistics of the variables used in the empirical tests.

|                         | count | mean   | sd    | p25   | p50   | p75   |
|-------------------------|-------|--------|-------|-------|-------|-------|
| **Main variables of interest** |       |        |       |       |       |       |
| ret_collapse            | 2505  | -37.52 | 22.85 | -52.40| -38.46| -25.96|
| FLEX                    | 1874  | 1.27   | 1.75  | 0.44  | 0.85  | 1.54  |
| Cash                    | 2518  | 0.26   | 0.29  | 0.04  | 0.13  | 0.41  |
| StdDebt                 | 2518  | 0.04   | 0.08  | 0.00  | 0.01  | 0.04  |
| LiDebt                  | 2510  | 0.25   | 0.23  | 0.05  | 0.22  | 0.39  |
| **Control variables**   |       |        |       |       |       |       |
| Beta                    | 2478  | 1.10   | 0.54  | 0.77  | 1.10  | 1.45  |
| bm                      | 2515  | 0.51   | 1.26  | 0.15  | 0.34  | 0.67  |
| Lmve                    | 2518  | 6.77   | 2.25  | 5.23  | 6.83  | 8.29  |
| Momentum                | 2478  | 0.24   | 1.03  | -0.15 | 0.15  | 0.44  |
| Profitability           | 2518  | 0.23   | 0.32  | 0.12  | 0.25  | 0.39  |
| Payout                  | 2518  | 0.03   | 0.06  | 0.00  | 0.01  | 0.04  |
| RD                      | 2518  | 0.10   | 0.19  | 0.00  | 0.02  | 0.12  |
| SGA                     | 2351  | 0.53   | 1.47  | 0.10  | 0.22  | 0.44  |
| COGS                    | 2510  | 0.57   | 0.29  | 0.37  | 0.61  | 0.79  |
| CAPX                    | 2501  | 0.04   | 0.05  | 0.01  | 0.03  | 0.05  |
| IG                      | 2518  | 0.12   | 0.32  | 0.00  | 0.00  | 0.00  |
| HY                      | 2518  | 0.15   | 0.36  | 0.00  | 0.00  | 0.00  |
| Covid_Exposure          | 1995  | 0.44   | 0.68  | 0.00  | 0.15  | 0.62  |
| **Other dependent variables** |       |        |       |       |       |       |
| ret_stimulus            | 2503  | 9.59   | 8.98  | 4.24  | 8.73  | 13.86 |
| vol-collapse            | 2505  | 7.18   | 3.24  | 5.17  | 6.45  | 8.32  |
| ivol-collapse           | 2505  | 6.20   | 3.58  | 4.01  | 5.41  | 7.45  |

Footnote: A simple dividend valuation model suggests that the market value \( J \) is proportional to expected future dividends, which in turn is proportional to productivity \( \theta \). Hence the market-to-book ratio \( J/K \) is positively related to the scaled productivity \( \theta/K \).
exposure are likely to be more in need of exercising their contraction options, and thus should find real flexibility more valuable.

We report the correlation matrix between the key variables of interest and the control variables in Table 2. These correlations are generally low in magnitude and therefore indicate that our later regression analyses do not suffer from serious multi-collinearity issues. The unconditional correlation between ret\_collapse and FLEX is positive, consistent with our expectation that real flexibility helps protect stock prices during the market crash. The signs of the correlations between ret\_collapse and the financial flexibility measures, i.e., cash, stdebt and ltdebt are also in line with Fahlenbrach et al.’s (2020) study, demonstrating that financially flexible firms suffered less during the market decline. The negative correlation between ret\_collapse and market beta illustrates the negative pricing of market risk during the collapse period.

4. Real flexibility and value resilience

4.1. Evidence from portfolio sorts

We divide firms into high and low FLEX groups according to the median level of FLEX within each intersection of size quintile and industry group, and plot the average cumulative excess returns for each FLEX portfolio in Fig. 4. The double-sorting before dividing into FLEX groups is to broadly control for firm characteristics so that the differences in returns between the two FLEX portfolios represent differences between similar firms. Fig. 4 demonstrates that the high-FLEX-group cumulative excess returns are higher than the low-FLEX-group cumulative excess returns. This result is in line with our Hypothesis 1 that real flexibility provides value resilience against negative productivity shocks during an economic downturn.

Furthermore, the return spread between high and low FLEX portfolios was small in the early half of the first quarter of 2020, when the market was relatively stable. However, the spread became sizable starting around February 21st, 2020, when the market began its sharp decline in reaction to the clearer signal that COVID-19 is a persistent health crisis that is causing real threats to the US economy, suggesting that the return spread is largely due to the COVID-19 shock. As the market declines further, we see an increased spread in the cumulative excess returns between the high-FLEX and low-FLEX portfolios, suggesting that the value of real flexibility is higher when the pandemic shock persists, and hence firms are closer to the threshold of exercising their contraction options. This evidence supports our Hypothesis 2.

4.2. Baseline regression analysis

The summary statistics in Table 1 reveal that there is a large cross-sectional variation in the collapse period cumulative excess returns of the firms in our sample. We test whether this variation can be explained by the firms’ differences in real flexibility, using the following regression model:

$$ ret\_collapse_i = \beta_0 + \beta_1 FLEX_i + \text{controls} + \text{Industry FE}_i + \epsilon_i. \quad (1) $$

Table 3 reports the regression estimates. Column (1) is the simple OLS regression of ret\_collapse on FLEX. Column (2) controls for Fama-French 49 industry fixed effects. Column (3) further controls for well-known characteristics in the asset pricing literature, i.e., firms’ equity beta, book-to-market, size, momentum and profitability. The significantly negative coefficient of equity beta represents the sharp decline of the market’s equity as a whole. The signs of the other controls are also in line with Fahlenbrach et al. (2020).

Moreover, in column (4), we control for other firm-level characteristics that may simultaneously correlate with FLEX and ret\_collapse. Capital expenditures (CAPX), research and development (RD) and selling, general and administrative expenses (SGA) are commonly used in proxying firms’ efforts in developing real options (see, e.g., Goyal et al., 2002; Cao et al., 2008; Eisfeldt & Papa-nikolaou, 2013; Del Viva et al., 2017). Table 2 shows that FLEX is negatively correlated CAPX, RD and SGA, implying that firms with higher development-related fixed costs typically are also less operationally flexible. Following Fahlenbrach et al. (2020), we also control for cost of goods sold (COGS), dividend payout ratio (payout), rating indicators for investment-grade (IG) and high-yield rating (HY). COGS and payout relate to the firm’s business model and are positively related to FLEX. The credit rating indicators IG and HY might capture additional information beyond our real flexibility measure FLEX. Table 2 shows that these variables are also correlated to ret\_collapse, and therefore it is important to control for them as well.

Throughout the different model specifications, the coefficient of FLEX is positive and statistically significant. Taking the estimate from column (4), we find that one standard deviation increase in FLEX reduces the collapse period return crash by 1.9%. To sum up, in line with Hypothesis 1, the above results suggest that firms with high real flexibility are less affected by the market decline during the COVID-19 economic downturn, and therefore exhibit lower price sensitivity. Importantly, contraction options provide a cushion against productivity shocks during economic downturns and thereby protect firms’ value.

4.3. Beyond financial flexibility

Previous studies find that financial flexibility cushions against the COVID-19 shock and reduces stock price crash risk (Fahlenbrach et al., 2020; He & Ren, 2022). Various recent studies also demonstrate that real flexibility affects debt capacity and capital structure

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9 In all regression models, we ensure that the right-hand-side variables are lagged behind the response variables. See Table B5 for a detailed description of how the time-horizons of the variables are defined.
Given that financial flexibility and capital structure are closely related (see, e.g., Byoun, 2011; Denis & McKeon, 2012; Bolton et al., 2020), it is therefore important to examine our findings about real flexibility in light of the benefits of financial flexibility. In this section, we systematically investigate the interplay between these two dimensions of financial flexibility and capital structure.

This table reports the correlation coefficients between the key variables of interest and the control variables in our sample. We omit the correlations among the control variables to save space. See Table B5 for more details about the definition of these variables. Statistical significance of the correlation coefficients is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.

### Table 2

Correlation matrix.

| Variables  | (1) ret_collapse | (2) FLEX | (3) cash | (4) stdebt | (5) ldebt | (6) beta | (7) bm | (8) lnve | (9) momentum | (10) profitability | (11) payout | (12) RD | (13) SGA | (14) COGS | (15) CAPX | (16) IG | (17) COGS |
|------------|-----------------|----------|----------|-----------|----------|---------|--------|---------|--------------|-------------------|-----------|--------|--------|---------|---------|--------|---------|
| (1) ret_collapse | 1.00          |          |          |           |          |         |        |         |               |                  |           |        |        |         |         |        |         |
| (2) FLEX    | 0.06***        | 1.00     |          |           |          |         |        |         |               |                  |           |        |        |         |         |        |         |
| (3) cash    | 0.21***        | -0.21*** | 1.00     |           |          |         |        |         |               |                  |           |        |        |         |         |        |         |
| (4) stdebt  | -0.03          | 0.11***  | -0.11*** | 1.00      |          |         |        |         |               |                  |           |        |        |         |         |        |         |
| (5) ldebt   | -0.21***       | 0.09***  | -0.36*** | 0.01      | 1.00     |         |        |         |               |                  |           |        |        |         |         |        |         |
| (6) beta    | -0.07***       | -0.06*** | 0.08***  | -0.13***  | 0.07***  |         |        |         |               |                  |           |        |        |         |         |        |         |
| (7) bm      | -0.07***       | 0.00     | -0.10*** | 0.06***   | -0.12*** | -0.02   |        |         |               |                  |           |        |        |         |         |        |         |
| (8) lnve    | 0.02           | 0.16***  | -0.24*** | -0.18***  | 0.24***  |         |        |         |               |                  |           |        |        |         |         |        |         |
| (9) momentum| 0.01           | 0.02     | 0.11***  | -0.08***  | -0.02    |         |        |         |               |                  |           |        |        |         |         |        |         |
| (10) profitability | -0.04*       | 0.05***  | -0.39*** | -0.05***  | 0.07***  |         |        |         |               |                  |           |        |        |         |         |        |         |
| (11) payout | 0.01           | 0.04*    | -0.11*** | 0.01      | 0.10***  |         |        |         |               |                  |           |        |        |         |         |        |         |
| (12) RD     | 0.17***        | -0.21*** | 0.66***  | 0.04***   | -0.24*** |         |        |         |               |                  |           |        |        |         |         |        |         |
| (13) SGA    | 0.04**         | -0.14*** | 0.25***  | 0.03      | -0.11*** |         |        |         |               |                  |           |        |        |         |         |        |         |
| (14) COGS   | -0.05***       | 0.25***  | -0.25*** | 0.14***   | 0.08***  |         |        |         |               |                  |           |        |        |         |         |        |         |
| (15) CAPX   | -0.14***       | -0.06**  | -0.24*** | -0.04***  | 0.13***  |         |        |         |               |                  |           |        |        |         |         |        |         |
| (16) IG     | 0.01           | 0.13***  | -0.20*** | 0.00      | 0.08***  |         |        |         |               |                  |           |        |        |         |         |        |         |
| (17) COGS   | -0.18***       | 0.06***  | -0.26*** | -0.03     | 0.34***  |         |        |         |               |                  |           |        |        |         |         |        |         |

Fig. 4. The evolution of mean cumulative daily excess returns for low and high FLEX portfolios during the first quarter of 2020. The sample consists of common stocks of the U.S. public non-financial firms that are listed on NYSE, AMEX, or NASDAQ. The portfolios are formed according to the median level of FLEX for each intersection of the size quintile and industry group. The double-sorting before dividing into FLEX groups is to broadly control for firm characteristics, so that the differences of returns between the two FLEX portfolios represent differences between similar firms.

(Gu et al., 2017; MacKay, 2003; Reinartz & Schmid, 2016).
firm flexibility in the context of the COVID-19 economic downturn.

### 4.3.1. Incremental protection

The correlation coefficients in Table 2 reveal that FLEX is positively associated with short-term and long-term debt, and negatively associated with cash holdings. These results are consistent with previous findings that real flexibility increases debt capacity (Gu et al., 2017; MacKay, 2003; Reinartz & Schmid, 2016). In light of this association between financial flexibility and real flexibility, the coefficients estimates of FLEX in the previous section without controlling for financial flexibility can be biased.

In Table 4, we also control for the various financial flexibility measures studied by Fahlenbrach et al. (2020). Firms with higher cash holdings, short-term or long-term debt are supposed to be more financially flexible. Our coefficient estimates of these measures all have signs in line with Fahlenbrach et al. (2020)'s findings that firms with higher financial flexibility cope better with the pandemic. Importantly, throughout columns (1)–(4), our estimates of the FLEX coefficient show that real flexibility unambiguously provides resilience against the pandemic shock, and that its benefit coexists with financial flexibility. Taking the estimate from column (4), we find that one standard deviation increase in FLEX reduces the collapse period return crash by 2.03%. This is comparable to the effects of cash, stdebt and ltdebt, i.e., 2.50%, 0.05% and 4.10%, respectively. These results demonstrate that real flexibility provides incremental protection against the COVID-19 shock beyond financial flexibility.

### 4.3.2. Complementary protection

Firms with lower financial flexibility are disadvantaged from obtaining financial aid in times of emergency and are therefore likely

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**Table 3**

Real flexibility and collapse period returns.

| ret_collapse | (1)          | (2)          | (3)          | (4)          |
|--------------|--------------|--------------|--------------|--------------|
| FLEX         | 0.72**       | 1.24***      | 1.01***      | 1.07***      |
|              | (2.05)       | (4.14)       | (3.08)       | (3.44)       |
| beta         | -6.04***     | -5.35***     | -4.56        | -1.99        |
|              | (-5.28)      | (-1.71)      | (-1.09)      | (-1.09)      |
| bm           | -0.67*       | -0.45        | -1.09        | -1.09        |
|              | (-1.71)      | (-1.71)      | (-1.71)      | (-1.71)      |
| lmve         | 0.76***      | 1.24***      | 0.67         | 0.67         |
|              | (3.12)       | (3.79)       | (1.71)       | (1.71)       |
| momentum     | -1.77**      | -1.75**      | -2.07        | -2.07        |
|              | (-2.07)      | (-2.07)      | (-2.07)      | (-2.07)      |
| profitability| 1.83         | 0.70         | 0.24         | 0.24         |
|              | (0.66)       | (0.66)       | (0.66)       | (0.66)       |
| payout       | 4.40         |              |              |              |
|              | (0.62)       |              |              |              |
| RD           | 22.35**      |              |              |              |
|              | (2.12)       |              |              |              |
| SGA          | -0.24        |              |              |              |
|              | (0.23)       |              |              |              |
| COGS         | 0.73         |              |              |              |
|              | (0.23)       |              |              |              |
| CAPX         | -16.73       |              |              |              |
|              | (-1.52)      |              |              |              |
| IG           | -3.48**      |              |              |              |
|              | (-2.49)      |              |              |              |
| HY           | -7.95***     |              |              |              |
|              | (-6.63)      |              |              |              |
| Constant     | -40.18***    | -40.84***    | -39.10***    | -41.30***    |
|              | (-60.24)     | (-67.94)     | (-14.57)     | (-9.97)      |
| Observations | 1865         | 1865         | 1860         | 1856         |
| Adjusted $R^2$ | 0.003        | 0.170        | 0.187        | 0.207        |
| Industry FE  | NO           | YES          | YES          |              |

This table reports the cross-sectional regression estimates under equation (1), for the test of Hypothesis 1 that the collapse period returns are less negative for firms with higher real flexibility (FLEX). The dependent variable ret collapse is the cumulative of daily excess returns between February 3rd, 2020 and March 23rd, 2020, when the U.S. stock market experienced large decline in response to the COVID-19 pandemic. Column (1) is the simple OLS regression of ret collapse on FLEX. Column (2) controls for Fama-French 49 industry fixed effects. Column (3) further controls for well-known characteristics in the asset pricing literature, i.e., firms’ equity beta, book-to-market, size, momentum and profitability. Column (4) also controls for other firm-level variables that may simultaneously correlate with FLEX and ret collapse. See Table B5 for more details about the definition of variables. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.

The corresponding figures reported by Fahlenbrach et al. (2020) are 3.5%, 1.3%, and 3.7%, respectively.
to be more in need of exercising their contraction options, and hence should find real flexibility more valuable. Following Fahlenbrach et al. (2020), we regard a firm as having low financial flexibility if it has low cash holdings, high short-term or long-term debt.

We sort the sample into high and low financial-flexibility groups using these proxies and report the sub-sample estimates in Table 5. Columns (1)–(2), (3)–(4) and (5)–(6) sort the sample into low and high cash, stdebt and ldtdebt groups, respectively. For example, a firm is classified as having high cash if its cash holdings is above the sample average. Our results show that the high-financial-flexibility groups do not display significant real flexibility effects, whereas the low-financial-flexibility groups consistently do; moreover, the magnitudes of FLEX are also higher for the low financial-flexibility firms than for the high financial-flexibility firms. Consequently, real flexibility provides complementary protection alongside financial flexibility. For firms that are not able to benefit from financial flexibility, real flexibility kicks in and becomes more important.

4.3.3. Multiplier effect

Conversely, it is also interesting to see whether the benefits of financial flexibility documented by Fahlenbrach et al. (2020) are conditional on real flexibility. To this aim, we separate the sample into high and low real-flexibility groups and report the sub-sample estimates in Table 6. As can be seen throughout the columns, the overall message of our results is clear — the protection of financial flexibility is stronger for firms with high real flexibility.

| Table 4 |
|---|
| Beyond financial flexibility: Real flexibility’s incremental protection. |
| ret_collapse | (1) | (2) | (3) | (4) |
| FLEX | 1.14*** | 1.10*** | 1.12*** | 1.16*** |
| cash | 13.49*** | (3.70) | 3.40 | (3.56) |
| stdebt | −5.75 | −.57 | −19.09*** | −17.81*** |
| ldtdebt | | | (−7.88) | (−6.92) |
| beta | −5.52*** | −5.37*** | −4.73*** | −4.90*** |
| bm | −0.42 | −.44 | −0.88** | −0.83** |
| lmve | 1.30*** | 1.20*** | 1.21*** | 1.24*** |
| momentum | −2.07** | −1.77** | −1.58* | −1.81** |
| profitability | −0.84 | −0.87 | −2.03 | −2.04 |
| payout | 0.75 | 4.88 | 9.19 | 6.56 |
| RD | 17.66 | 22.88** | 18.74* | 16.02 |
| SGA | −0.62 | −0.25 | −0.85 | −1.09 |
| COGS | 1.51 | 0.86 | −1.98 | −1.24 |
| CAPX | −13.69 | −16.89 | −13.50 | −11.77 |
| IG | −2.95** | −3.35** | −2.51* | −2.22 |
| HY | −7.30*** | −7.94*** | −4.44*** | −4.26*** |
|Constant | −43.86*** | −40.83*** | −35.10*** | −37.10*** |
|Observations | 1856 | 1856 | 1850 | 1850 |
|Adjusted R² | 0.214 | 0.207 | 0.235 | 0.237 |
|Industry FE | YES | YES | YES | YES |

This table reports the cross-sectional regression estimates under equation (1), for the test of Hypothesis 1 that the collapse period returns are less negative for firms with higher real flexibility (FLEX). In addition to the vector of controls adopted in Table 3, here columns (1)–(4) also control for various financial flexibility measures. Firms with higher cash holdings, lower short-term debts and long-term debts are considered to be more financially flexible. See Table B5 for more details about the definition of variables. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.

We sort the sample into high and low financial-flexibility groups using these proxies and report the sub-sample estimates in Table 5. Columns (1)–(2), (3)–(4) and (5)–(6) sort the sample into low and high cash, stdebt and ldtdebt groups, respectively. For example, a firm is classified as having high cash if its cash holdings is above the sample average. Our results show that the high-financial-flexibility groups do not display significant real flexibility effects, whereas the low-financial-flexibility groups consistently do; moreover, the magnitudes of FLEX are also higher for the low financial-flexibility firms than for the high financial-flexibility firms. Consequently, real flexibility provides complementary protection alongside financial flexibility. For firms that are not able to benefit from financial flexibility, real flexibility kicks in and becomes more important.
These results are consistent with the notion that real flexibility provides a “multiplier effect” for financial flexibility. That is to say, in order for a firm’s real flexibility to exhibit its contribution, the firm must first overcome a threshold level of fixed costs associated with exercising its contraction option.\(^\text{11}\) During the economic downturn when firms typically have lower-than-usual levels of cash in hand, they may not be able to overcome such thresholds. For firms with low real flexibility which have formidable high option-exercising barriers, financial flexibility cannot reap the additional “bonus” brought about by real flexibility and therefore exhibits weaker effects on safeguarding stock prices. On the other hand, firms that have lower option-exercising barriers can more readily have their real flexibility’s benefits “activated” and “monetarized” and thus multiply the role of financial flexibility.

### 4.4. Sub-sample heterogeneity

To understand better the mechanism behind the value of FLEX, we conduct sub-sample analyses in light of Hypothesis 2. That is, if the value of FLEX comes as a result of flexible firms being easier to cut down their scales to match with the reduced productivity levels, then this effect should be more pronounced for firms that are more likely to, or more in need of, exercising such contraction options.

\(^{11}\) In the notation of the HJ model, this relates to the model parameter \(f_0\). Specifically, upon disinvestment, the firm incurs a fixed cost of \(f_0\theta^\gamma K\).
4.4.2. COVID-19 exposure

Firms with more pandemic exposure are likely to be more in need of exercising their contraction options, and thus should find real flexibility more valuable. Parallel to the above analysis, we sort the sample into high and low COVID-19 exposure groups, and re-
Table 7
Real flexibility and collapse period returns: High/low book-to-market subsamples.

| ret_collapse | (1) | (2) | (3) | (4) |
|--------------|-----|-----|-----|-----|
|              | By BM unconditionally | By BM within industry |
| Low          | High |
| Low          | High |
| FLEX         | 0.13 | 2.04*** | 0.74* | 1.69*** |
|              | (0.32) | (4.55) | (1.92) | (3.92) |
| cash         | 9.95* | 2.91 | 5.86 | 6.54 |
|              | (1.66) | (0.52) | (0.97) | (1.17) |
| stdebt       | 2.32 | –30.65** | 3.42 | –21.13 |
|              | (0.17) | (-2.50) | (0.24) | (-1.63) |
| ltdebt       | –17.72*** | –31.52*** | –18.59*** | –28.03*** |
|              | (-4.91) | (-6.67) | (-5.38) | (-5.53) |
| beta         | –5.65*** | –2.97* | –5.93*** | –2.84 |
|              | (-3.70) | (-1.76) | (-4.00) | (-1.60) |
| bm           | –2.15** | –0.50* | –3.47** | –0.49 |
|              | (-1.98) | (-1.95) | (-2.30) | (-1.52) |
| lnv          | 2.47*** | –0.10 | 2.09*** | 0.06 |
|              | (4.46) | (-0.22) | (3.94) | (0.12) |
| momentum     | –1.33 | –3.51** | –1.77* | –2.89* |
|              | (-1.42) | (-2.08) | (-1.92) | (-1.85) |
| profitability| –4.38 | 0.26 | –4.67 | –0.69 |
|              | (-1.01) | (0.05) | (-1.15) | (-0.13) |
| payout       | 6.49 | –12.51 | 9.30 | –16.67 |
|              | (0.70) | (-0.96) | (1.01) | (-1.35) |
| RD           | 25.91* | –5.78 | 21.11 | –1.21 |
|              | (1.86) | (-0.27) | (1.46) | (-0.06) |
| SGA          | –0.93 | –1.78** | –0.17 | –2.65*** |
|              | (-0.51) | (-2.05) | (-0.10) | (-3.88) |
| COGS         | 3.36 | –3.98 | 1.27 | –4.00 |
|              | (0.77) | (-0.89) | (0.29) | (-0.85) |
| CAPX         | –5.64 | –16.11 | –11.18 | –10.03 |
|              | (-0.35) | (-1.11) | (-0.77) | (-0.61) |
| IG           | –2.09 | –1.69 | –3.34* | –1.67 |
|              | (-1.11) | (-0.76) | (-1.83) | (-0.70) |
| HY           | –2.57 | –3.12* | –3.33* | –3.37* |
|              | (-1.42) | (-1.73) | (-1.95) | (-1.72) |
| Constant     | –45.75*** | –26.63*** | –41.64*** | –27.42*** |
|              | (-6.75) | (-4.34) | (-6.35) | (-4.18) |

This table reports the cross-sectional regression estimates under equation (1), separately for high and low book-to-market (BM) groups, for the test of Hypothesis 2 that the benefits of real flexibility are more pronounced for high BM firms compared with low BM firms. The dependent variable is the cumulative of daily excess returns between February 3rd, 2020 and March 23rd, 2020, when the U.S. stock market experienced large decline in response to the COVID-19 pandemic. See Table B5 for more details about the definition of variables. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.

To sum up, the above results demonstrate that, in line with Hypothesis 2, firms that are more in need of the contraction options, i.e., firms with high book-to-market ratios or high COVID-19 exposure, derive greater benefits from real flexibility during the economic downturn.

5. Further analysis

5.1. Endogeneity

The COVID-19 pandemic, due to its suddenness, severity and unpredictability, is widely regarded as a classic example of an exogenous shock ( Albuquerque et al., 2020; Hartmann, 2020; Verbeke, 2020). Therefore, one can hardly conceive how real flexibility FLEX, measured using firm fundamentals prior to the calendar year-end of 2019, could be reversely affected by the anticipation of the stock market over the coming pandemic. Nevertheless, to further demonstrate that our main results do not suffer from endogeneity...
issues, in this section, we conduct tests employing instrumental variables (IV) estimations and the propensity score matching (PSM) method.\textsuperscript{12}

First, following the approach of a wealth of economic studies, we instrumentalize FLEX with its lagged values (see, e.g., Hansen & Tarp, 2001; Dustmann, 2005; Ndikumana, 2005; Reed, 2015; Fu et al., 2020). These are unlikely to be affected by stock market shocks in the remote future and therefore are exogenous candidates as instruments. We estimate the two-stage least-square regressions (2SLS) for the structural-form equation (1) and report the results in Table 9. In columns (1)–(3), FLEX lagged by one, two and three years, respectively, are used as instruments for real flexibility. The Anderson-Rubin F-statistics are all highly significant, showing that these lagged variables are valid instruments for FLEX and our estimates are unlikely to suffer from biases associated with weak instruments (Staiger & Stock, 1997; Stock & Yogo, 2005, pp. 80–108). The coefficients of the instrumentalized real flexibility (\textit{FLEX}_\text{IV}) are all positive and statistically significant at 1% level, confirming our main findings.

Second, we instrumentalize FLEX with its industry medians, following Kini and Williams (2012).\textsuperscript{13} These are exogenous instrument

\textsuperscript{12} We thank an anonymous reviewer for suggesting these tests.

\textsuperscript{13} Unlike Kini and Williams (2012) where identification, when controlling for industry fixed effects, comes from the time-serious variation of their industry medians, our sample is cross-sectional. We achieve identification by constructing industry medians based on 3-digit SIC codes. Industries comprising of a single firm are dropped from our analysis.
candidates because they, being at the industry level, are unlikely to be affected by firm-level disturbances in stock prices. The Anderson-Rubin F-statistic in Table 9 column (4) show that the industrial median also is a valid instrument. Importantly, the coefficient of FLEX is positive and statistically significant, again confirming our key results.

Last, we evaluate the exogenous effect of FLEX on the collapse period returns via the PSM approach (Rosenbaum and Rubin, 1985). We classify firms into the treatment (control) group if its FLEX value is above (below) its industry-median level. We then use all control variables used in the baseline regression to estimate the firms’ propensity to be treated with the logistic regression. Each firm in the treatment group is subsequently matched to a firm in the control group based on the predicted propensity scores. Unmatched firms exhibit observable differences in their characteristics. This may indicate a presence of unobserved heterogeneity that affects the FLEX effect unequally between the treated and control firms. Therefore, removing these firms can mitigate bias concerns associated with omitted correlated variables (Dehejia & Wahba, 2002; Ni & Yin, 2018).

Table 9 Panel A shows that our matched sample is balanced for all of the control variables. In particular, the mean-difference t-statistic for each control variable shows that those control variables are not significantly different between the treatment and the control groups. Moreover, the standardized biases of all the control variables are low. This means that the treatment and control

| Table 9 | Real flexibility and collapse period returns: Instrumental variable estimations. |
|-------|-------|-------|-------|-------|
| ret_collapse | (1) | (2) | (3) | (4) |
| FLEX | 1.78*** | 1.37*** | 1.43*** | 1.36** |
| | (3.51) | (4.74) | (4.20) | (2.50) |
| cash | 8.52*** | 7.03* | 8.57*** | 8.50** |
| | (2.20) | (1.78) | (2.17) | (2.18) |
| stdebt | –11.25 | –11.66 | –6.24 | –1.05 |
| | (-1.41) | (-1.47) | (-0.76) | (-0.10) |
| ldebt | –16.74*** | –17.43*** | –17.69*** | –17.50*** |
| | (-6.77) | (-7.01) | (-6.87) | (-6.83) |
| beta | –5.11*** | –5.23*** | –4.98*** | –4.83*** |
| | (-4.34) | (-4.42) | (-4.26) | (-4.19) |
| bm | –0.29 | –0.31 | –0.40* | –0.83* |
| | (-1.19) | (-1.30) | (-1.66) | (-2.28) |
| lmve | 1.37*** | 1.40*** | 1.42*** | 1.14*** |
| | (4.26) | (4.39) | (4.32) | (3.53) |
| momentum | –1.68** | –2.07** | –2.30** | –1.71** |
| | (-2.02) | (-2.43) | (-2.40) | (-2.08) |
| profitability | –2.12 | –1.31 | –0.83 | –2.74 |
| | (-0.69) | (-0.41) | (-0.26) | (-0.86) |
| payout | 8.91 | 8.60 | 9.13 | 7.96 |
| | (1.19) | (1.13) | (1.20) | (1.10) |
| RD | 22.13* | 23.16* | 16.21 | 16.22 |
| | (1.75) | (1.78) | (1.36) | (1.49) |
| SGA | –1.53* | –1.25 | –2.25** | –1.12 |
| | (-1.76) | (-1.12) | (-2.05) | (-1.02) |
| COGS | –1.46 | –1.23 | –1.06 | –1.83 |
| | (-0.45) | (-0.38) | (-0.33) | (-0.56) |
| CAPX | –12.37 | –6.14 | –8.43 | –10.57 |
| | (-1.16) | (-0.59) | (-0.78) | (-0.98) |
| IG | –3.12** | –2.92** | –3.28** | –2.05 |
| | (-2.29) | (-2.12) | (-2.33) | (-1.51) |
| HY | –4.63*** | –4.39*** | –4.65*** | –4.47*** |
| | (-3.61) | (-3.36) | (-3.46) | (-3.51) |
| Constant | –17.10*** | –17.24*** | –17.59*** | –19.77*** |
| | (-2.96) | (-2.97) | (-3.11) | (-4.65) |

This table reports the two-stage least-square regression estimates for the structural-form equation (1), with the key explanatory variable FLEX being instrumentalized by its lagged values (columns 1–3) and industry median levels (column 4). FLEX is the respective predicted real flexibility generated from the 1st stage regressions. The dependent variable, ret_collapse, is the cumulative daily excess returns between February 3rd, 2020 and March 23rd, 2020. See Table B5 for more details about the definition of variables. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1. The standardised % bias is the difference of the treated and control group-means as a percentage of the square root of the average of the sample variances in the two groups (Rosenbaum and Rubin, 1985).
groups are identical in terms of potential confounders of real flexibility. Therefore, the status of being treated is orthogonal to firm characteristics, and hence any difference in the outcome variable ret_collapse may be credibly attributed to whether the firm has high or low real flexibility. Panel B of Table 10 shows that the average treatment effect on the treated (ATET) is 2.83% and statistically significant. This demonstrates that, everything else being equal, firms derive economically meaningful protection from real flexibility. Finally, we rerun our baseline regressions on the matched sample and report the estimates in Panel C of Table 10. The regression results on the matched sample are consistent with our baseline results. This shows that our key findings are unlikely driven by unobservable differences in firm characteristics.

5.2. Falsification tests

To address the concern that our results might be due to random effects related to the FLEX measure, we perform placebo tests by replacing FLEX with supposedly noisy values that are unlikely related to real flexibility. Presumably, if those noisy values could exhibit correlation with the collapse period returns, then the above-found effect of FLEX is spurious. We examine two substitutions of FLEX in this exercise: (i) by the firms’ name rank in alphabetical order; (ii) by a randomly generated variable following the standard-normal distribution. We report the results in Table 11. The table shows that neither of the alternative placebo FLEX measures is significantly related to the collapse period returns, and therefore confirms the validity of our baseline results.

Table 10
Real flexibility and collapse period returns: Propensity score matching.

| Panel A: Balance tests in the matched sample | Mean for treated group | Mean for control group | t-statistic | Standardized bias (%) |
|--------------------------------------------|------------------------|------------------------|------------|-----------------------|
| cash                                       | 0.118                  | 0.116                  | 0.32       | 1.2                   |
| stdebt                                     | 0.035                  | 0.035                  | –0.07      | –0.3                  |
| ltdebt                                     | 0.304                  | 0.314                  | –1.01      | –4.7                  |
| beta                                       | 1.097                  | 1.073                  | 1.04       | 4.6                   |
| hmn                                        | 0.562                  | 0.576                  | –0.22      | –1.0                  |
| lmve                                       | 7.638                  | 7.497                  | 1.44       | 6.4                   |
| momentum                                   | 0.242                  | 0.214                  | 1.32       | 4.8                   |
| profitability                              | 0.328                  | 0.326                  | 0.24       | 1.0                   |
| payout                                     | 0.044                  | 0.043                  | 0.38       | 1.7                   |
| RD                                         | 0.022                  | 0.019                  | 1.56       | 3.7                   |
| SGA                                        | 0.237                  | 0.223                  | 1.82       | 1.5                   |
| COGS                                       | 0.604                  | 0.611                  | –0.74      | –3.2                  |
| CAPX                                       | 0.043                  | 0.046                  | –1.56      | –6.3                  |
| IG                                         | 0.203                  | 0.195                  | 0.46       | 2.4                   |
| HY                                         | 0.225                  | 0.229                  | –0.22      | –1.1                  |

| Panel B: The treatment effect of real flexibility on the collapse period returns | Average treatment effect on the treated | t-statistic |
|-------------------------------------------------------------------------------|------------------------------------------|-------------|
| ret_collapse                                                                  | 2.83%                                    | 2.30**      |

| Panel C: Baseline regressions on the propensity score matched sample |
|---------------------------------------------------------------------|
| ret_collapse (1) |
| FLEX                  | 1.43***                  |
| (4.92)                |
| (2)                    |
| Observations          | 1383                     |
| Adjusted R²           | 0.197                    |
| Controls              | NO                       |
| Industry FE           | YES                      |
| ret_collapse (2) |
| FLEX                  | 1.36***                  |
| (3.96)                |
| Observations          | 1383                     |
| Adjusted R²           | 0.288                    |
| Controls              | YES                      |
| Industry FE           | YES                      |

This table reports the results of our propensity score matching (PSM) analysis. A firm is classified into the treatment (control) group if its real flexibility FLEX is above (below) its industry-median level. Firms are matched based on the PSM method employing all the control variables as propensity covariates. Panel A documents the balancing statistics for the matched sample. Panel B reports the average treatment effect on the treated (ATET) to measure the effect of FLEX on the collapse period return ret_collapse. Panel C reports the estimates of our baseline regressions on the matched sample. See Table B5 for more details about the definition of variables. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.

The approach (i) resembles Bai et al. (2021) who replace the Work-From-Home index with the position of firm name by alphabetic order in their falsification test.
5.3. Real flexibility and stimulus day returns

As an alternative test, we also consider the returns on March 24th, 2020, when the Federal Open Market Committee stimulus package news propagated through the U.S. stock markets. The announcement of the financial aid package should be viewed by investors as a positive news in the context of an economic downturn. Therefore, the lower price sensitivity of high real flexibility firms, as implied by our Proposition, should result in a lesser dramatic reaction of those firms’ prices. Consequently, we expect high real flexibility firms to have less-positive returns on the stimulus day, March 24th, 2020. We re-estimate equation (1) by replacing the response variable with the stimulus day return \( \text{ret}_{\text{stimulus}} \) and report the results in Table 12. As can be seen, the coefficient estimates of FLEX is now significantly negative, after controlling for industry fixed effects, the firm level controls, and financial flexibility measures.

5.4. Real flexibility and return volatility

Given the same level of productivity uncertainty, firms whose values are less sensitive to productivity shocks should also exhibit less-volatile prices. Following this logic, we expect real flexibility to play a role in reducing return volatility during the collapse period. We test this hypothesis using the following regression model,

\[
\text{vol}_{\text{collapse}} = \beta_0 + \beta_1 \text{FLEX} + \text{controls} + \text{Industry FE} + \epsilon. 
\]

Table 11
Real flexibility and collapse period returns: Falsification tests.

| ret_collapse | (1) | (2) | (3) | (4) | (5) | (6) |
|--------------|-----|-----|-----|-----|-----|-----|
| FLEXfalsi    | 0.00| -0.00| -0.00| 0.07| 0.07| 0.08|
| Cash         | 8.15**| (2.06) | (0.16)| 8.13**| (2.06)| (0.17)| (0.19) |
| Stdebt       | 1.75| (0.16)| 1.79| (0.17)|
| Ltebt        | -17.64***| (6.79)| -17.64***| (6.79)|
| Beta         | -5.60***| (4.78)| -5.17***| (4.79)| -5.60***| (4.79) |
| Bm           | -0.41| (0.98)| -0.79**| (2.13)| -0.41| (0.98)| -0.79**| (2.13) |
| Lmve         | 1.43***| (4.37)| 1.46***| (4.36)| 1.43***| (4.36) |
| Momentum     | -1.80**| (-2.14)| -1.85**| (-2.14)| -1 (4.37) |
| profitability| 0.01| (0.15)| 0.00| (0.15)|
| payout       | 3.90| (0.55)| 3.86| (0.54)| 3.92| (0.54)|
| RD           | 21.43**| (2.05)| 21.44**| (2.05)| 21.43**| (2.05) |
| SGA          | -0.29| (0.05)| -0.29| (0.05)|
| COGS         | 2.65| (0.03)| 2.65| (0.03)|
| CAPX         | -19.11*| (0.83)| -14.35| (0.83)| -19.06*| (0.83) |
| IG           | -3.42**| (-1.75)| -2.25| (-1.75)| -3.41**| (-1.75)| -2.24| (-1.75) |
| HY           | -7.86***| (6.65)| -4.23***| (6.65)| -7.85***| (6.56)| -4.22***| (6.56) |
| Constant     | -39.28***| (-40.81)| -38.12***| (-38.20) |
| Observations | 1865| 1856| 1850| 1865| 1856| 1850|
| Adjusted \( R^2 \) | 0.161| 0.201| 0.230| 0.161| 0.201| 0.230|
| Industry FE  | YES| YES| YES| YES| YES| YES|

This table reports the cross-sectional regression estimates under equation (1), with FLEX replaced by values that are supposedly noisy and unrelated to real flexibility. The dependent variable is the cumulative of daily excess returns between February 3rd, 2020 and March 23rd, 2020, when the U.S. stock market experienced large decline in response to the COVID-19 pandemic. The columns vary in controls of firm level characteristics. See Table B5 for more details about the definition of variables. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.
We conjecture that \( \beta_1 < 0 \) under this specification, and report evidence for this conjecture in Table 13. The raw return volatility is the standard deviation of the daily excess returns during the collapse period, whereas the beta-adjusted return volatility differs only by replacing the daily excess returns with returns adjusted for the market risk before the standard deviation computation, i.e., beta-adjusted return = daily excess returns − \( \beta \times \) market daily excess return. Table 13 shows that FLEX has a significant negative impact on both versions of return volatility when controlling for various sets of firm-level characteristics.

In addition, parallel to section 4.4, we examine the mechanism of volatility-reduction through sub-sample analyses and report our findings in Table 14. Our results show that real flexibility’s role in reducing return volatility is more pronounced for firms with high book-to-market ratios or high COVID-19 exposure. These findings support the notion that the volatility-reduction effect of FLEX is via the channel of firms’ necessity in exercising their contraction options.

The current COVID-19 studies also report several firm characteristics’ impact on the pandemic period return volatility. Albuquerque et al. (2020) show that stocks with higher Environmental and Social ratings have lower return volatility. Sinagl (2020) documents higher return volatility for industries with higher cash-flow risk. Bai et al. (2021) find evidence that firms with better Work-From-Home feasibility have lower return volatility. Alongside these studies, our results reveal that real flexibility plays an important role in reducing return volatility.

### Table 12
Real flexibility and stimulus day returns.

| ret_stimulus | (1) | (2) | (3) | (4) | (5) | (6) |
|--------------|-----|-----|-----|-----|-----|-----|
| FLEX         | -0.15 | -0.27* | -0.26* | -0.31** | -0.28* | -0.31** |
|              | (-1.25) | (-1.78) | (-1.75) | (-2.33) | (-1.82) | (-2.31) |
| cash         | 1.12 | 9.30** | 9.58** | 2.67* | 1.90 | 2.79 |
| stdebt       | 1.12 | 9.30** | 9.58** | 2.67* | 1.90 | 2.79 |
| ldebt        | 1.12 | 9.30** | 9.58** | 2.67* | 1.90 | 2.79 |
| beta         | 2.05*** | 2.03*** | 2.09*** | 1.94*** | 1.93*** |
|              | (4.00) | (3.96) | (4.09) | (3.82) | (3.81) |
| bm           | 0.02 | 0.03 | 0.00 | 0.09 | 0.08 | 0.07 |
| lmve         | 0.56*** | 0.57*** | 0.64*** | 0.57*** | 0.66*** |
|              | (3.86) | (3.88) | (4.41) | (3.94) | (4.56) |
| momentum     | 1.05*** | 1.02*** | 1.08*** | 1.02*** | 0.98*** |
|              | (2.85) | (2.74) | (2.94) | (2.77) | (2.62) |
| profitability | 1.82 | 1.81 | 2.10 | 2.05 | 2.33* |
|              | (1.39) | (1.38) | (1.63) | (1.53) | (1.77) |
| payout       | -0.06 | -0.37 | -0.82 | -0.58 | -2.16 |
|              | (-0.02) | (-0.11) | (-0.25) | (-0.17) | (-0.61) |
| RD           | -4.30 | -4.69 | -5.16* | -3.62 | -5.40* |
|              | (-1.36) | (-1.48) | (-1.70) | (-1.15) | (-1.76) |
| SGA          | 0.30 | 0.27 | 0.30 | 0.34 | 0.27 |
|              | (1.19) | (1.04) | (1.24) | (1.27) | (0.99) |
| COGS         | -0.07 | -0.00 | -0.27 | 0.47 | 0.47 |
|              | (-0.05) | (-0.00) | (-0.19) | (0.33) | (0.33) |
| CAPX         | 4.43 | 4.69 | 4.70 | 4.36 | 5.21 |
|              | (0.83) | (0.88) | (0.89) | (0.82) | (0.99) |
| IG           | 0.05 | 0.09 | -0.16 | -0.13 | -0.25 |
|              | (0.07) | (0.13) | (-0.23) | (-0.18) | (-0.35) |
| HY           | 1.83*** | 1.88*** | 1.81*** | 1.25** | 1.32** |
|              | (3.13) | (3.19) | (3.11) | (2.01) | (2.12) |
| Constant     | 10.27*** | 2.90* | 2.68 | 2.13 | 1.83 |
|              | (38.96) | (1.71) | (1.55) | (1.25) | (1.04) |
| Observations | 1863 | 1854 | 1854 | 1854 | 1848 |
| Adjusted R²  | 0.061 | 0.119 | 0.119 | 0.124 | 0.123 |
| Industry FE  | YES | YES | YES | YES | YES |

This table reports the cross-sectional regression estimates under equation (1), but with the response variable replaced by the stimulus day returns (ret_stimulus), for testing the conjecture that the collapse period returns are less positive for firms with higher real flexibility (FLEX), demonstrating lower price-sensitivity. The dependent variable is the stimulus daily excess return on March 24th 2020, when the U.S. stock market reacted positively to the stimulus package announced by the Federal Reserve. Column (1) controls for Fama-French 49 industry fixed effects. Column (2) further controls for firms’ equity beta, book-to-market, size, momentum and profitability. Columns (3–6) also control for various financial flexibility measures. Firms with higher cash holdings, lower short-term debts and long-term debts are supposed to be more financially flexible. See Table B5 for more details about the definition of variables. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.
5.5. Real flexibility and earnings

Although our proposition focuses on the price sensitivity to productivity shocks, the model should have similar implications on corporate earnings. Everything else being equal, under a large productivity shock, inflexible firms are likely to remain far from their target (optimal) capital level $K^*_{t}$ and hence experience reduced profit stream, due to their formidably high contraction-frictions; on the other hand, flexible firms are able to adapt their scales and therefore improve its profit stream. In this section, we empirically examine the relation between corporate earnings and real flexibility.

We use the same sample of U.S. non-financial firms from the main tests but obtain their quarterly return-on-assets (ROA) from the Compustat Fundamentals quarterly dataset during the calendar years 2019 and 2020. In contrast to the stock sample where we consider the collapse period of February 3rd to March 23rd, 2020, here we look into the entire year 2020 because the pandemic’s impact on the corporate earnings continued to show in the latter part of the year when business activities declined in response to case rises and social-distancing and lockdown policies. The mechanism behind the lead-lag relation between stock prices and earnings is well understood in the classic asset-pricing theory — stock prices are forward-looking and therefore reacts earlier than earnings which capture realized cash flows of the firm. See Fig. 5 to visualize the time series of stock prices and earnings.

To test the effect of real flexibility on corporate earnings, we estimate the following panel regression model,

$$\text{ROA}_{i,t} = \beta_0 + \beta_1 \text{FLEX}_{i,t-1} + \text{controls} + \text{Industry} \& \text{Time FE} + \epsilon_{i,t}.$$  (3)

FLEX and the controls variables are lagged by one quarter. The summary statistics for this exercise are given in Table B1.

|            | (1)       | (2)       | (3)       | (4)       | (5)       | (6)       |
|------------|-----------|-----------|-----------|-----------|-----------|-----------|
| FLEX       | −0.20***  | −0.06**   | −0.08***  | −0.25***  | −0.06*    | −0.08**   |
| cash       | −1.99***  | −1.56***  | −1.99***  | −1.56***  |           |           |
| stdebt     | 0.52      | 0.97      | 0.51      | 0.94      |           |           |
| ltdebt     | 2.62***   | 2.78***   | (2.92)    | 2.62***   |           |           |
| beta       | 1.42***   | 1.35***   | 1.40***   | 1.32***   |           |           |
| bm         | 0.01**    | 0.21***   | 0.21**    | 0.26***   |           |           |
| lmve       | −0.44***  | −0.44***  | −0.64***  | −0.64***  |           |           |
| momentum   | −0.04     | −0.01     | −0.16     | −0.14     |           |           |
| profitability | −0.49    | −0.26     | −0.33     | −0.07     |           |           |
| payout     | −0.57     | −0.30     | −0.66     |           |           |           |
| RD         | 3.02**    | 4.15***   | 3.45**    | 4.40***   |           |           |
| SGA        | 0.15      | 0.25*     | 0.13      | 0.21      |           |           |
| COGS       | 0.25      | 0.53      | 0.35      |           |           |           |
| CAPX       | 4.40**    | 3.49**    | 5.20***   | 4.38**    |           |           |
| IG         | 0.28      | 0.07      | 0.27      | 0.06      |           |           |
| HY         | 0.88***   | 0.31*     | 0.92***   | 0.34*     |           |           |
| Constant   | 7.15***   | 7.89***   | 6.12***   | 7.62***   |           |           |
| Observations | 1865     | 1856      | 1850      | 1865      | 1856      | 1850      |
| Adjusted $R^2$ | 0.140    | 0.292     | 0.332     | 0.133     | 0.359     | 0.393     |
| Industry FE | YES       | YES       | YES       | YES       | YES       | YES       |

This table reports the cross-sectional regression estimates under equation (2), for the test of the hypothesis that the collapse period return volatility is lower for firms with higher real flexibility (FLEX). The dependent variable is the standard deviation of the daily (raw or beta-adjusted) excess returns between February 3rd, 2020 and March 23rd, 2020, when the U.S. stock market experienced large decline in response to the COVID-19 pandemic. The columns vary in controls of firm level characteristics. See Table B5 for more details about the definition of variables. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
We first estimate equation (3) for the full 2019 and 2020 sample and report the estimates in Table 15. Column (1) reports the estimates for the 2019 & 2020 sample. Our estimate on the FLEX coefficient shows that real flexibility benefits earnings during 2019 and 2020. Next, we compare the value of FLEX in sustaining earnings between 2019 and 2020, by estimating equation (3) for the 2019 and 2020 sub-samples separately. We expect the real-flexibility effect to be stronger during 2020, when contraction options are much more needed. Columns (2) and (3) are estimates for the 2019 and 2020 sub-samples, respectively, and show that the FLEX coefficient is indeed much larger in magnitude during 2020 compared with 2019.16

Our findings here complement several COVID-19 studies. Li et al. (2020) demonstrate that firms with stronger corporate culture have a higher ROA. Teng et al. (2021) show that financial flexibility has a significant and positive effect on enterprise performance. Our work demonstrates that real flexibility helps with firms’ both stock market and financial performances during the pandemic.

6. Conclusion

The economic disruption brought about by the COVID-19 pandemic is unlike before in its suddenness and severity. Its unwelcome advent has important implications for the stock market efficiency (Capelle-Blancard & Desroziers, 2020; Lalwani & Meshram, 2020; 16 These results are robust to restricting the sample to 2019Q3-2020Q2, see Table B3.
Vasileiou, 2021), banking and monetary policies (Tholl et al., 2020; Nozawa & Qiu, 2021), effective government intervention tactics (Ashraf, 2020; Baker et al., 2020; Zaremba et al., 2020), and the imminent transformation of capital relocation and resources management that promotes investments in sustainable business models (Caligiuri et al., 2020; Shankar, 2020; Verbeke, 2020). On the other hand, the consequent exogenous shock also provides a unique setting for exploring a range of important corporate issues, and accordingly has facilitated a wide variety of empirical studies, such as in profit warning qualities and agency conflicts (Brennan et al., 2021; Liu & Tian, 2021). Whilst a burgeoning literature has attempted to explain why some firms seem to be more resilient to the shock than do others (see, e.g., Ding et al., 2021), the benefits of flexibility associated with real options remain largely unexplored. However, agile firms that are able to timely reduce the amount of unproductive capital should also suffer less. Therefore, it is important to examine the role of real options in corporate performance during the pandemic.

In this paper, we study the benefits of real flexibility in terms of firm value’s response to a sudden negative productivity shock, by employing Hackbarth and Johnson (2015)’s investment-based asset pricing model with built-in real options for the firm to contract (expand) its business in bad (good) times. We show that the firm value’s sensitivity to productivity shocks is inversely related to its flexibility in exercising the contraction option. The model therefore predicts that flexible firms are less adversely impacted by large negative productivity shocks. Furthermore, we demonstrate that the risk-reduction effect of real flexibility is more pronounced when the firm is closer to its contraction-option exercising threshold.

We test the above predictions empirically using the sample of U.S. non-financial firms and find that more flexible firms did experience less price drop during the early-stage decline period of the pandemic in Spring 2020. The findings are robust to controlling for various financial flexibility measures; therefore, real flexibility provides additional value resilience beyond that of financial flexibility documented in Fahlenbrach et al. (2020). Besides, subsample analyses reveal that real flexibility not only provides complementary protection alongside financial flexibility, but also boosts the benefits of financial flexibility. We further show that the real-flexibility effect is more pronounced for firms with higher book-to-market ratio or more COVID-19 exposure, consistent with the idea that the benefits of real flexibility are associated primarily with contraction options, rather than expansion options, during the COVID-19 crisis. Moreover, we find that real flexibility also reduces return volatility during the early decline period of the pandemic. Lastly, we demonstrate that real flexibility helps firms sustain earnings as well, especially during 2020 when the pandemic struck, compared with 2019.

Our work contributes to the growing literature examining the benefits of real flexibility. Prior literature documents that real options affect firms’ investment policies, risk and return patterns and financing decisions. Our paper extends this line of research by providing a new dimension on the value of resilience derived from real flexibility during economic crises. Our findings have important implications for investors with their portfolio selection. Risk-averse investors are advised to factor real flexibility into their consideration in order to protect their wealth against unexpected catastrophic events, given that such crises may return. Besides, the relevance of firm value protection in the context of economic downturns should be taken into account by corporate managers when evaluating the strategic benefits and costs of real-options-induced flexibility (Herhausen et al., 2021).
Data availability

Data will be made available on request.

Appendix A. Proofs

Proof of the Proposition.

By definition of the stochastic discount factor \( \Lambda \), the expected excess return is

\[
EER \ dt = - \text{cov} \left( \frac{dJ}{J} \frac{d\Lambda}{\Lambda} \right).
\]

where \( J = J(\theta, K) \). During inaction periods, the only stochastic increment of \( J \) comes from \( d\theta \), i.e., \( dJ = \frac{\partial J}{\partial \theta} d\theta + \text{deterministic increments} \), therefore

\[
\text{cov} \left( \frac{dJ}{J} \frac{d\Lambda}{\Lambda} \right) = \text{cov} \left( \frac{1}{J} \frac{dJ}{\partial \theta} \frac{d\Lambda}{\Lambda} \right) = \frac{\partial J}{\partial \theta} \text{cov} \left( \frac{d\theta}{\theta} \frac{d\Lambda}{\Lambda} \right).
\]
The covariance term in the last expression is the negative of the $\theta$ risk premium $\pi_\theta dt$, and its coefficient is precisely the firm's value-productivity elasticity $\varepsilon$. Therefore, \[ EER dt = -\varepsilon \times (\pi_\theta dt) = \varepsilon \pi_\theta dt. \] Rearranging yields $\varepsilon = \frac{EER}{\pi_\theta}$. In the HJ model, the price of the productivity risk $\pi_\theta$ is a positive constant, therefore, the decomposition of $\varepsilon$ and the monotonicity of the components precisely follow those of $EER$, which are proven in Hack Barth and Johnson (2015)'s Proposition 3.

Appendix B. Additional Tables

Table B1 reports the summary statistics of the variables used in the earnings tests in Section 5.5. All explanatory variables and controls are lagged by one quarter behind ROA. The definitions of these variables follow the same methods as their annual counterparts, see Table B5 for more details.

Table B.2 reports the panel unit root test statistics for the variables used in the earnings tests in Section 5.5. The credit ratings indicators IG and HY are constant throughout the sample period, and are thus excluded from the panel unit root tests. The table shows that none of the variables suffers from non-stationarity issues. Therefore, our empirical estimates are not affected by spurious regressions.

Table B3 repeats the earnings tests in Section 5.5, but restricts the sample to 2019Q3-2020Q2. This exercise is conducted in view of the observation that the corporate earnings plunge occurs mostly during 2020Q1-Q2, see Fig. 5.

Utility firms are typically excluded in asset-pricing studies because they are heavily regulated. For example, Bates et al. (2009) argue that the cash holdings of utility firms may be subject to regulatory supervision. We follow this convention in our empirical tests in the main text. This is also done so that our analyses may be directly comparable with that of Fahlenbrach et al. (2020). However, here in Table B4, we also illustratively report the estimates of some of the cross-sectional regressions in the main text when we include utility firms into the sample as well. Panel A repeats the tests of real flexibility and collapse period returns in Tables 3 and 4. Panel B repeats the earnings tests in Table 15. The remaining tests are available upon request. The results are almost identical to those of the baseline sample. This shows that our findings are not sensitive to sample selection choices with respect to utility firms.

Table B5 gives the definition of variables used in our empirical tests.

Table B.1
Summary statistics of the variables used in the earnings tests

| Variable | count | mean  | sd  | p25  | p50  | p75  |
|----------|-------|-------|-----|------|------|------|
| ROA      | 19,503| -3.45 | 11.06 | -4.39 | 0.10 | 1.59 |
| FLEX     | 14,655| 1.22  | 1.63 | 0.44 | 0.82 | 1.48 |
| cash     | 19,543| 0.26  | 0.29 | 0.05 | 0.14 | 0.41 |
| stdebt   | 19,015| 0.07  | 0.04 | 0.00 | 0.01 | 0.04 |
| ltdebt   | 19,424| 0.23  | 0.37 | 0.05 | 0.23 | 0.40 |
| beta     | 19,311| 0.63  | 0.68 | 0.16 | 0.36 | 0.72 |
| bmn      | 19,279| 0.53  | 0.68 | 0.16 | 0.36 | 0.72 |
| lmve     | 19,309| 6.76  | 2.19 | 5.23 | 6.80 | 8.25 |
| momentum | 19,322| 0.02  | 0.36 | -0.19| -0.01| 0.17 |
| profitability | 19,467| 0.06  | 0.09 | 0.03 | 0.06 | 0.10 |
| payout   | 19,508| 0.04  | 0.07 | 0.00 | 0.01 | 0.04 |
| RD       | 19,513| 0.03  | 0.05 | 0.00 | 0.00 | 0.03 |
| SGA      | 18,376| 0.47  | 1.14 | 0.09 | 0.22 | 0.44 |
| COGS     | 19,263| 0.57  | 0.29 | 0.37 | 0.61 | 0.79 |
| CAPX     | 19,331| 0.02  | 0.03 | 0.00 | 0.01 | 0.03 |
| IG       | 19,615| 0.12  | 0.32 | 0.00 | 0.00 | 0.00 |
| HY       | 19,615| 0.15  | 0.36 | 0.00 | 0.00 | 0.00 |

This table reports the summary statistics of the quarterly observations of the return on assets (ROA), real flexibility (FLEX), financial flexibility measures (cash, stdebt and ltdebt), and control variables of the same sample of firms used in the main tests. All explanatory variables and controls are lagged by one quarter behind ROA. The definitions of these variables follow the same methods as their annual counterparts, see Table B5 for more details.

Table B.2
Panel unit root tests for the quarterly earnings sample

| Variables | $\chi^2$  | Degree of freedom | p-value |
|-----------|-----------|-------------------|---------|
| ROA       | 12600***  | 4998              | 0.0000  |
| FLEX      | 9101***   | 3774              | 0.0000  |
| cash      | 11500***  | 5002              | 0.0000  |
| stdebt    | 32300***  | 4924              | 0.0000  |
| ltdebt    | 23900***  | 4990              | 0.0000  |
| beta      | 14500***  | 5008              | 0.0000  |
| momentum  | 23200***  | 5008              | 0.0000  |
| lmve      | 8551***   | 5000              | 0.0000  |
| bm        | 10100***  | 4994              | 0.0000  |

(continued on next page)
Table B.2 (continued)

| Variables | $\chi^2$  | Degree of freedom | p-value |
|-----------|----------|-------------------|---------|
| profitability | 13300*** | 4990 | 0.0000 |
| payout | 27800*** | 4998 | 0.0000 |
| RD | 8940*** | 4984 | 0.0000 |
| SGA | 10600*** | 4718 | 0.0000 |
| COGS | 11800*** | 4948 | 0.0000 |
| CAPX | 18300*** | 4986 | 0.0000 |

This table reports the panel unit root test statistics for the variables used in the ROA tests. We follow Choi (2001) and obtain the corresponding $\chi^2$ statistics of the Fisher-type tests based on ADF tests allowing for time trend. Very positive values of $\chi^2$ lend evidence for stationarity of the variables being tested. Statistical significance of the tests is indicated according to p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.

Table B.3
Real flexibility and earnings: The 2019Q3-2020Q2 sample

| ROA | (1) | (2) | (3) |
|-----|-----|-----|-----|
|      | 2019Q3-2020Q2 | 2019Q3-Q4 | 2020Q1-Q2 |
| FLEX | 0.13*** | 0.09** | 0.17*** |
| cash | 1.67** | 0.81 | 2.53** |
| stdebt | -9.11*** | -9.72*** | -8.51** |
| ldebt | -1.47*** | -2.39*** | -0.45 |
| beta | -0.25 | -0.07 | -0.42* |
| bm | 0.02 | -0.18 | 0.19 |
| lnve | 0.75*** | 0.70*** | 0.78*** |
| momentum | 1.53*** | 1.16** | 1.97*** |
| profitability | 18.76*** | 20.11*** | 17.36*** |
| payout | 7.09*** | 7.13*** | 7.39*** |
| RD | -101.31*** | -99.29*** | -103.90*** |
| SGA | -2.24*** | -2.09*** | -2.38*** |
| COGS | -1.65*** | -2.13*** | -0.99 |
| CAPX | -3.13 | -5.63 | -1.99 |
| IG | -1.21*** | -1.12*** | -1.24*** |
| HY | -0.22 | -0.19 | -0.22 |
| Constant | -4.10*** | -2.93** | -5.34*** |

| Observations | 6888 | 3572 | 3316 |
| Adjusted $R^2$ | 0.406 | 0.445 | 0.370 |
| Industry FE | YES | YES | YES |
| Time FE | YES | YES | YES |

This table reports the regression estimates under equation (3). The dependent variable is the quarterly return-on-assets (ROA). Column (1) reports the estimates for the 2019Q3-2020Q2 sample. Columns (2) and (3) show the estimates for the 2019Q3-Q4 and 2020Q1-Q2 subsamples separately. All columns control for the vector of firm-level characteristics used in the main tests, together with Fama-French 49 industry fixed effects, and time fixed effects. The time identifier for each quarterly observation is the fiscal quarter end date. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.
Table B.4
Including utility firms into the sample

| Panel A: Real flexibility and collapse period returns |
|-----------------------------------------------|
| ret_collapse (1) (2) (3) (4) (5) (6) |
| FLEX 1.20*** 1.08*** 1.15*** 1.11*** 1.13*** 1.17*** |
| (4.00) (3.54) (3.80) (3.49) (3.67) (3.74) |
| cash 13.20*** 8.26** |
| (3.64) (2.11) |
| stdebt | -5.57 |
| (0.55) |
| lndebt | -18.75*** |
| (7.53) |

| Observations 1951 1942 1942 1942 1936 1936 |
| Adjusted $R^2$ 0.166 0.200 0.207 0.200 0.226 0.228 |
| Controls NO YES YES YES YES YES |
| Industry FE YES YES YES YES YES YES |

| Panel B: Real flexibility and corporate earnings |
|-----------------------------------------------|
| ROA (1) (2) (3) |
| 2019 & 2020 0.12*** 0.09*** 0.16*** |
| (5.45) (3.61) (4.34) |
| cash 0.55 0.36 0.79 |
| (1.11) (0.52) (1.10) |
| stdebt | -8.26*** |
| (5.63) |
| lndebt | -1.90*** |
| (5.47) |

| Observations 14,701 7395 7306 |
| Adjusted $R^2$ 0.407 0.458 0.364 |
| Controls YES YES YES |
| Industry FE YES YES YES |
| Time FE YES YES YES |

In this table, we illustratively report the estimates of some of the cross-sectional regressions in the main text when we include utility firms into the sample as well. Panel A repeats the tests of real flexibility and collapse period returns in Tables 3 and 4. Panel B repeats the earnings tests in Table 15. See Table B5 for details about the definition of variables. T-statistics are given in the parentheses. Statistical significance is indicated according to the p-value as: ***p < 0.01, **p < 0.05, *p < 0.1.

Table B.5
Definition of variables

| Variable | Definition |
|----------|------------|
| ret_collapse | Firm’s cumulative daily excess returns in % between February 3rd 2020 and March 23rd 2020. |
| FLEX | Firm level real flexibility, as defined by FLEX = 1/INFLEX. Following Gu et al. (2017, eq.7), INFLEX is the firm level inflexibility defined as the firm’s 5-year historical range of quarterly operating costs over sales, up to the calendar year end of 2019, scaled by the volatility of the quarterly changes in the logarithm of sales over assets. |
| beta | Equity beta, estimated as the slope parameter of a regression of daily log excess returns on daily market log excess returns from January 2nd to December 31st of calendar year 2019. We use the S&P 500 index to proxy for the market. |
| bm | The ratio of book value of equity (CEQ) to market value of equity at the end of 2019, where the market value of equity is the last observation of daily close price (PRCCD) at year end 2019 multiplied with the number of shares outstanding (GSHOC). CEQ values are taken as the latest figures by January 31, 2020 according to Compustat datadate. This is true for all the accounting fundamentals used in our sample. |
| lmve | The natural logarithm of the firm’s market value of equity at calendar year end 2019. |
| momentum | The cumulative of daily excess returns during calendar year 2019. |
| profitability | Gross profit (GP) scaled by total assets (AT). |
| cash | Cash holdings (CHE) scaled by total assets. |
| stdebt | Debt in current liabilities (DLC) scaled by total assets. |
| lndebt | Total long-term debt (DLTT) scaled by total assets. |
| payout | Total dividends (DVC + DVP) and share repurchases (PRSTKC) scaled by total assets. Missing or negative values of DVC, DVP, and PRSTKC are set to zero, following Fahlenbrach et al. (2020). |
| RD | Total research and development expenses (XRD) scaled by total assets. Missing values of XRD are set to zero. |
| SGA | Selling, general and administrative expenses (XSGA) scaled by total sales (SALE). |
| COGS | The cost of goods sold (Compustat item COGS) scaled by total sales. |

(continued on next page)
Table B.5 (continued)

| Variable          | Definition                                                                                                                                 |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| CAPX              | Capital expenditures (CAPX) scaled by lagged total assets.                                                                                |
| IG                | A dummy variable indicating investment grade according to S&P’s domestic long-term issuer credit rating. It is set to one if the Compustat item SPLTICRM is at least at BB level and set to zero otherwise. We take SPLTICRM values at the end of February 2017 because it is only available up to then. |
| HY                | A dummy variable indicating high-yield grade according to S&P’s domestic long-term issuer credit rating. It is set to one if the Compustat item SPLTICRM is between BB and C and set to zero otherwise. |
| Covid_Exposure    | Individual firms’ exposure to COVID-19, taken from Hassan et al. (2020)’s online repository.                                                |
| ret_stimulus      | Firm’s excess return in % on March 24th/2020, when the market reacted positively to the stimulus package announced by the Federal Reserve and the Federal Open Market Committee. |
| (i)vol_collapse   | Firm’s standard deviation of daily excess returns in % between February 3rd 2020 and March 23rd 2020. ivol_collapse is obtained likewise using beta-adjusted returns instead. |
| ROA               | Quarterly return-on-assets in %, defined as quarterly Income Before Extraordinary Items (IBCOMQ) scaled by lagged quarterly total assets (ATQ). |
| Other quarterly variables | These variables follow closely the definitions of their annual counterparts. All accounting fundamentals are taken from the Compustat Quarterly dataset. Beta and momentum are computed over the three-month windows corresponding to the quarter with one lag behind the ROA values. |

This table describes the definition of all variables used in our empirical tests. Capitalized letters in the paratheses in the Definition column refer to Compustat variables.

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