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Collaborative integration, workplace flexibility and scholarly productivity: Evidence from the COVID-19 outbreak

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1. Introduction

Scholarly productivity is an important measure of knowledge-building activities at the micro level, which poses broad implications for enhancing the knowledge-based economy (Hamermesh & Oster, 2002; Ponomariov & Boardman, 2010; Powell & Snellman, 2004). Under a canonical Person–Environment Fit framework (Shin, 2004), in addition to personal characteristics, there are primarily two external factors that affect research productivity, i.e., interpersonal collaboration and work environment (Vuong et al., 2019). However in the digital era, the rapid development of internet and communication technology (ICT) has profoundly changed traditional patterns of collaboration and work environment into virtual teams and remote work arrangements, posing confounding impacts on scholarly productivity (Hamermesh & Oster, 2002; Townsend et al., 1998; Vuong et al., 2019). Regarding whether virtual teams and remote work facilitate or hinder general productivity, the current literature focuses on the static impact of these factors based on cohort comparisons and makes conflicting remarks (Bailey & Kurland, 2002; Bayrak, 2012; Koellinger, 2006). Such ambiguous directions of the impact are largely driven by endogeneity challenges, as variance in collaboration integration and work flexibility is highly correlated with economic and technology development and cohort-specific characteristics (Hamermesh & Oster, 2002; Vuong et al., 2019). Meanwhile, more evidence is needed for scholarly productivity in the knowledge-intensive sector, which relies more on collective knowledge transfer and self-management/discipline (Agrawal & Goldfarb, 2008; Bagnara & Marti, 2001; Bailey & Kurland, 2002).

To fill in the research gaps, this paper identifies the role of collaborative integration and work flexibility in scholarly productivity based on exogenous shocks. Specifically, we exploit the natural experiment of the COVID-19 outbreak and investigate its impact on the quantity and quality of scholars’ journal and working paper submissions. Meanwhile, as massive public health interventions have been implemented nationwide in China during the coronavirus crisis,1 we further exploit mitigation policy shocks such as social distancing and working-from-home orders to test whether collaborative integration and workplace flexibility as potential transition channels account for single-authorship and coauthorship differences in scholarly productivity, verifying the role of collaborative integration, work flexibility, and psychological costs.

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1 List of China’s government/institution measures in response to COVID-19 can be found at https://www.china-briefing.com/news/china-covid-19-policy-tracker-benefiting-business-enterprises-comprehensive-updated-list/
Our empirical strategy is based on the discontinuity of submissions from Chinese scholars around the Chinese New Year (CNY) associated with the “holiday effects.” CNY is based on the Chinese lunar calendar, taking place either at the end of January or in February. Officials, it is a seven-day public holiday and is the most important family festival for the Chinese people, who heavily emphasize family values, making family reunions an important tradition during the CNY period (Tan et al., 2009). Therefore, the holiday effects on the scholarly output level could be significantly negative during the CNY week, and it could lead to large fluctuations in productivity during the weeks that are adjacent to CNY. More importantly, Fig. 1 tabulates the COVID-19 situation around the 2020 Chinese New Year (CNY) in terms of the number of confirmed cases and deaths, and we find that the 2020 CNY week highly overlapped with the hiking of the COVID-19 outbreak in China. Scholars from other countries could serve as the counterfactual control group. First, they do not experience the CNY holiday break. Second, before the WHO declared the COVID-19 outbreak a pandemic on March 11, the vast majority of laboratory-confirmed infections had occurred in mainland China, which inclines the confounding factors in the experiment around the 2020 CNY week. Hence, we could employ difference-in-differences models to test the productivity discontinuity around CNY for Chinese scholars and further test the effect of COVID-19 on scholarly productivity and its impact channels based on a triple difference strategy.

Based on the paper submission records collected from the online submission system of a peer-reviewed journal and the webpage of the Social Science Research Network within the specific academic context of real estate and urban economics, we find that 1) there is a discontinuity pattern in the productivity of Chinese scholars around the CNY. Chinese scholars tend to increase the journal submission propensity one week before the CNY; their submission propensity drops during the CNY week and recovers gradually post-CNY. 2) COVID-19 has a negative impact on scholarly productivity in terms of quantity and quality. For Chinese scholars, their submission pace accelerated after the outbreak, represented by the slower recovery of journal submissions post-CNY and a higher propensity of journal submissions pre-CNY, while their papers were more likely to be desk rejected under such circumstances. 3) COVID-19 affects short-term scholarly productivity mainly through the channel of collaborative integration and workplace flexibility. Collaboration could in general mitigate the negative effect of exogenous shocks, while virtual communication cannot effectively substitute face-to-face meetings in knowledge production. Higher workplace flexibility could strengthen the negative effect of exogenous shocks on productivity through potential factors such as self-discipline and technology frictions. The role of psychological costs, such as stress and panic during epidemic development, is relatively limited.

Our findings provide both theoretical and practical implications. It contributes to the literature on (scholarly) productivity and collaboration under the ICT support, identifying the causal relationship between collaboration integration and productivity development (Hamermesh & Oster, 2002). It also adds to the literature on productivity and remote work associated with a higher degree of time and location flexibility, with new evidence from the academic sector relying more on self-management and self-discipline (Bailey & Kurland, 2002). The unique merit of our research data enables understanding of the underlying mechanisms of the knowledge production process from both quantity and quality perspectives. It further broadens the evaluation of COVID-19 effects apart from the well-documented effects on consumption, business operations, public health, demographics, and capital markets (Atkeson, 2020).

The organization of the paper is as follows. Section 2 describes the data used in our study and the empirical design. Section 3 presents the empirical results of the discontinuity baseline of the CNY effects and the scholarly productivity response to COVID-19 and provides robustness checks based on placebo tests, eliminating confounding factors, and cross-validity tests. Section 4 discusses the potential channels through which the COVID-19 outbreak might negatively affect the scholarly production of the journal and working papers in the short term, including collaborative integration, workplace flexibility, and psychological costs. Section 5 presents our conclusions and contributions.

2 Theoretical background

Under a canonical and broad-based Person–Environment Fit framework, in addition to personal factors, there are primarily two external factors that affect the adjusted (research) productivity, i.e., collaboration and work environment (Vuong et al., 2019). Extending the framework in a digital economy, the literature highlights the incorporation of ICT supports further reshapes the role of collaboration and work environment in impacting productivity under the emergence of virtual teams and remote work arrangements (Shin, 2004; Townsend et al., 1998). Deeper insights have been gained into the impact and transmission channel of these ICT supports in general productivity, which is especially vital in the knowledge production process of the academic sector relying more on complex information transfer, and skills of self-management and self-discipline.

2.1. Collaboration: communication costs and modes

As to the collaboration factor, the literature suggests that researchers benefit significantly from collaboration, as collaboration can provide information, reassurance, and practical help when researchers encounter inevitable difficulties (Ragana & Marti, 2001; Parry et al., 1997). Studies highlight the cost reduction effects of advances in communication (i.e., facilitating conditions from BITNET adoption) and transportation technologies (such as flight or high-
Hypothesis 1. Collaboration could mitigate the negative effect of COVID-19 as exogenous shocks in general, while pandemic mitigation policies shifting the mode of communications pose detrimental effects on the productivity of coauthorship scholars, as virtual communication limits the richness of in-person communication in conveying and/or converging on complex ideas to achieve efficient collaborative integration.
productivity goals, especially for academic jobs that relatively do not experience frequent performance evaluations. Meanwhile, the academic sector relies more on skills of self-management and self-discipline; and as a measure of work-life balance, work hours in the academic sector are more flexible. Since scholars in the discipline of our research interest are less dependent on the resources or equipment in the laboratory, the WFH order upon the COVID-19 outbreak serves as a natural experiment to detect the role of workplace flexibility on scholarly productivity. As remote work cross multiple physical, temporal, and psychological boundaries (Clark, 2000), the chances for work and nonwork roles to conflict are relatively high for the academic sector, which enhances negative consequences to productivity (Raghuram & Wiesenfeld, 2004). Especially for the single-authorship group, the only difference between office and home work is the schedule control and work-life balance. Hence, we derive the second hypothesis,

**Hypothesis 2.** WFH interventions as pandemic mitigation policies altering the boundary of the work environment deepen the negative effect of COVID-19 on productivity, as remote work amplifies interference issues in workplace flexibility when people are less motivated by self-discipline.

### 2.3. COVID-19 crisis-related effects

As addressed, mitigation measures amid the COVID-19 outbreak could serve as a valid exogenous shock to disentangle the role of intellectual collaboration and the difference between virtual and interpersonal communication in collaborative integration, which deals with endogeneity between collaboration integration and technology development (Hamermesh & Oster, 2002). In addition to the above-mentioned impact channel through altering collaboration and work environment, “crisis-related effects” such as psychological costs are also significantly amplified under drastic COVID-19 crises.

People have a high mental toll as facing isolation, risk of infection, as well as inadequate information and supplies. Literature has long suggested that a major outbreak of novel and fatal epidemic disease can be quickly followed by plagues of fear, panic, suspicion, and stigma (Strong, 1990). Recent work in The Lancet reports negative psychological effects of restriction of movement of people who have potentially been exposed to a contagious disease under the COVID-19 outbreak (Brooks et al., 2020). In addition, though a freer working environment has small but favorable effects on perceived autonomy and job satisfaction (Gajendran & Harrison, 2007), it is found that workers who work from home are plausibly experiencing conditions of time famine, which is a pervasive feeling of having insufficient time in daily life (Perlow, 1999). This could lead to stress, anxiety, and psychic costs (Choudhury et al., 2020). Moreover, it is a transfer of risk that any risks involved in fluctuating productivity that arise from flexible working conditions are displaced onto the individual worker (Beck, 1990), which would cause self-inflicted stress and will be amplified by remote work orders under health crises. However, there is limited knowledge about what happens when academic researchers face psychological costs when moving from their offices in academia, especially in an environment with drastic changes and substantial uncertainties (Fan, 2022). In addition, it is still not clear regarding the relative importance of the psychological cost as a subjective channel compared with other objective channels in affecting productivity.

### 3. Data and empirical design

#### 3.1. Data

Our data come from three sources. The first proprietary data about paper submission records are collected from the online submission system of a peer-reviewed journal in the field of real estate and urban economics from January 1, 2015, until March 24, 2020. These data contain information on the paper characteristics, including submission date and time, and the status of the paper (whether it is desk rejected, rejected, minor/major revised or accepted, which could serve as a proxy for paper quality). Some basic information about the characteristics of the author (as the submitter) is also accessible, including the author’s identifier and the country of the author’s affiliation, as well as the coauthorship (whether she has any coauthors of this paper). For confidentiality reasons, we cannot access information on the institutional identifier of the submitters or information on countries with fewer than 10 submissions; thus, we focus only on countries or regions with more than 10 submissions in our empirical study. As an extension of related studies based on publication records or patents (see Hoekman et al. (2008), among others), our study based on submission records can address selection bias and provide evidence from both the quantity and quality perspectives. In addition, factors from the referee side could be eliminated.

Our second dataset is collected from the webpage of the Social Science Research Network (SSRN) (https://papers.ssrn.com), focusing on submissions in the field of urban economics and regional studies.

2. As comparable considerations, we restrict the observation period to January 1, 2015, until March 24, 2020. For each paper, we can access the information of all authors (including name, affiliation, and country), the characteristics of the paper (including title, length in pages, whether the paper is a working paper or has been accepted by journals, and number of downloads), as well as the upload and revision dates. With such information, we could further identify whether the authors of each paper come from the same institution.

The third dataset provides dynamic information on governmental policies related to the COVID-19 pandemic in each country. The data are collected from the Oxford COVID-19 Government Response Tracker, which contains policy details on government responses in terms of policy measures (such as school closures, travel bans, etc., recorded on an ordinal scale and rescaled to vary from 0 to 100) and financial measures (such as fiscal or monetary measures). These data also contain dynamic information on confirmed COVID-19 deaths and case numbers by country. We merged these data with the journal submission data or the SSRN submission data based on the country and date of submission.

Our final observation period is from January 1, 2015, to March 24, 2020. Table 1 shows the statistical description of key variables based on data from peer-reviewed journal submissions (3238 records) and SSRN submissions (8302 records in total, 2325 records in the “working paper series”) in the field of real estate and urban economics. From Table 1, we find limited statistical bias between the treatments and controls. In empirical studies, we further extend these two unbalanced panel data to balanced panel data, from which we could acquire the information on the submission propensity for each scholar on a given date.

#### 3.2. Empirical design

##### 3.2.1. Discontinuity around CNV

In this paper, we investigate the impact of COVID-19 and corresponding mitigation policies, exploiting the discontinuity around the
Chinese New Year. During our sample period (2015–2020), we can observe the dynamics of journal and SSRN submissions in 6 rounds of CNY breaks. Hence, we first exploit a difference-in-difference (DD) framework to identify that in general, there is a discontinuity pattern in the productivity of Chinese scholars around CNY each year due to the “holiday effect”. Then, using a difference-in-difference-in-difference (DDD) strategy based on panel data, we detect a further dampening effect of the COVID-19 outbreak on the productivity of Chinese scholars around the CNY break in 2020.

Specifically, we first tabulate the discontinuity in the submission propensity of Chinese scholars, who are identified as submitters from mainland China. We focus on the window around CNY, during which the Chinese are celebrating holidays with their families; their submission behavior will be affected by leisure complementarities, which is in line with the holiday effects detected in the literature on job search, industrial production and pollution issues (Baker & Fradkin, 2017; Sun, 2013; Tan et al., 2009).

Fig. 2 exhibits the distribution of submission and desk rejection rates of new journal submissions around CNY. The blue bar demonstrates the submission rate, and by comparing the Chinese and non-Chinese cohorts, we find a clear discontinuity for the Chinese submitters. Specifically, the propensity of new submissions hikes one week prior to CNY, reaches an extremely low level during CNY, and slowly recovers in the two weeks post-CNY. Note that the submission propensity of the Chinese seems to be systematically higher than that of the non-Chinese in 2020, which might be induced by a steeper trend in journal submissions from the Chinese in recent years. The red bar demonstrates the rejection rate as a direct proxy for the quality of new submissions. Briefly, we find that the rejection rate is relatively stable for non-Chinese submitters; in contrast, the rejection rate is significantly higher for Chinese submitters when the submission is close to the CNY week. Such patterns of submission and rejection propensities are more obvious in 2020 than in previous years.

We further provide the regression discontinuity (RD) test around the CNY week in Fig. 3. Focusing on the blue line, which is the 4th-order global polynomial fit of the submission propensity for Chinese contributors each week, we find a significant discontinuity pattern in the submission distribution of the Chinese around CNY, and this identified holiday effect serves as an intuitive validity test of the COVID-19 impact on scholarly productivity using Chinese scholars as the treatment group.

### 3.2.2. Baseline models

In the first step, we employ difference-in-differences (DD) models to test the statistical and economic significance of the discontinuity pattern observed above. Based on the discontinuity, we set the CNY week as the omitted reference week and set the treatment group as the Chinese submitters (scholars based in mainland China). The DD empirical model is as follows.

\[
Y_{h,p,t} = \alpha + \beta_0 \text{Chineseh}_t \times 1(CNY_t) + \beta_1 \text{Chineseh}_t \times 1(\text{preCNY}_t) + \beta_2 \text{Chineseh}_t \times 1(\text{postCNY}_t) + \delta_t + \eta_h + \epsilon_{h,p,t}
\]

where \(Y_{h,p,t}\) denotes the average propensity to submit (%) and the propensity of desk rejection for new submissions (%) from scholar \(h\) in country \(p\) at year-month \(t\). \(\text{Chineseh}_t\) is a treatment dummy for Chinese submitters according to the country information. \(1(CNY_t)\) is an indicator equal to 1 if the submission is made during the CNY week in each year. \(1(\text{preCNY}_t)\) is an indicator equal to 1 if the submission is made one week before the CNY, while \(1(\text{postCNY}_t)\) is a dummy variable equal to 1 if the submission is made one week after the CNY in each year. We also include a full set of author fixed effects, \(\eta_h\), to capture author-level unobserved characteristics such as habits. The year-month fixed effect, \(\delta_t\), is also included to account for the submission trend. Additionally, the author-by-year-month fixed effect, \(\epsilon_{h,p,t}\), is incorporated to capture the dynamic productivity of the scholar. The standard errors are clustered at the country level to account for the autocorrelation within a specific country. \(\beta_1\), \(\beta_2\), and \(\beta_3\) are key coefficients of interest. Significantly positive (negative) coefficients of these DD terms indicate that there is a productivity increase (decline) around the CNY week for the treatment group; a statistically weaker effect of \(\beta_3\), as \(\beta_0\), implies a recovery process in productivity.

To detect the productivity effect from the COVID-19 shock, we further employ a difference-in-difference-in-differences (DDD) estimate. Our baseline regression model is as follows.

\[
Y_{h,p,t} = \alpha + \beta_0 \text{Chineseh}_t \times 1(CNY_t) \times 1(\text{COVID}_t) + \beta_1 \text{Chineseh}_t \times 1(\text{preCNY}_t) \times 1(\text{COVID}_t) + \beta_2 \text{Chineseh}_t \times 1(\text{postCNY}_t) \times 1(\text{COVID}_t) + \delta_t + \eta_h + \epsilon_{h,p,t} + \epsilon_{h,p,t}
\]

where \(1(\text{COVID}_t)\) is an indicator equal to 1 if the submission is made after the outbreak of COVID-19 in China (January 20, 2020). As of

### Table 1

Summary Statistics.

|                      | Control Group |                | Treatment Group |                | Difference  |
|----------------------|---------------|----------------|-----------------|----------------|-------------|
|                      | Mean | Sd               | Mean | Sd               | Mean |                     |
| **Panel A: Journal Submission** |                  |                  |                  |                  |                  |
| Submitted during CNY week (Yes=1) | 0.037 | 0.189               | 0.019 | 0.137           | 0.018 * *        |
| Submitted in weekends (Yes=1) | 0.072 | 0.259               | 0.127 | 0.333           | -0.055 ** ***    |
| Submitted in off-hours (Yes=1) | 0.359 | 0.480               | 0.537 | 0.499           | -0.177 ** ***    |
| Coauthor (Yes=1) | 0.978 | 0.147               | 0.968 | 0.176           | 0.010 *          |
| Desk Rejection (Yes=1) | 0.236 | 0.436               | 0.333 | 0.472           | -0.078 ** ***    |
| Acceptation (Yes=1) | 0.103 | 0.303               | 0.079 | 0.271           | 0.023           |
| **Panel B: SSRN Submission** |                  |                  |                  |                  |                  |
| Submitted during CNY week (Yes=1) | 0.031 | 0.174               | 0.025 | 0.156           | 0.007           |
| Submitted in weekends (Yes=1) | 0.075 | 0.264               | 0.074 | 0.202           | 0.014           |
| Coauthor (Yes=1) | 0.731 | 0.432               | 0.762 | 0.427           | -0.031           |
| Same Affiliation (Yes=1) | 0.348 | 0.477               | 0.361 | 0.482           | -0.012           |
| Revised (Yes=1) | 0.757 | 0.429               | 0.803 | 0.399           | -0.046           |
| Paper Series (Accepted Paper=1) | 0.373 | 0.484               | 0.410 | 0.494           | -0.037           |
| Number of Downloads | 78.520 | 247.284               | 65.881 | 76.188           | 12.639           |

Notes: This table reports the summary statistics of our baseline sample. Panel A provides a detailed summary of journal submissions (3238 records) collected from a peer-reviewed journal in the field of real estate and urban economics, while Panel B provides a summary of SSRN submissions (8302 records in total, 2325 records in the “Working Paper Series”) also in the field of real estate and urban economics. * ** p < 0.01, * * p < 0.05, * p < 0.1.
January 20, 2020, President Xi Jinping ordered resolute efforts to curb the spread of the novel coronavirus (previously named 2019-nCoV) that caused cases of pneumonia and ordered heightened attention and all-out prevention and control efforts.\textsuperscript{10}

3.2.3. Identification validity

The validity of our DD model relies on the parallel trend assumption. Specifically, we assume that in the absence of the CNY holiday, Chinese and non-Chinese submitters should follow similar trends in the propensity of new submissions; the validity of this identification assumption could be examined by looking at the dynamic differences of submission propensity between the Chinese (the treatment group) and the non-Chinese (the control group). The empirical model is as follows.

\[
\text{submission}_{h,p,t} = \alpha + \sum_{r=4}^{4} \beta_r \Delta \text{CNY} + \delta_{t} + \eta_h + \sigma_{p,y} + \epsilon_{h,p,t} \tag{3}
\]

where \(\text{submission}_{h,p,t}\) denotes the average propensity to submit (%) for scholar \(h\) in country \(p\) at year-month \(t\). \(\Delta \text{CNY} = \tau\) is a relative week dummy measuring the time difference equal to the CNY week, which equals 1 if \(\Delta \text{CNY} = \tau\). The first day of the CNY holiday in each year is normalized as period 0. \(\text{Chinese}_h\) is a treatment dummy for Chinese submitters according to the country information.

Fig. 4(a) exhibits the pretrend test as supportive evidence for the identification assumption. The vertical solid line indicates the CNY week in each year, while the x-axis denotes the week difference to CNY. Consistent with Fig. 2, it suggests that the trends of submission propensity (%) two weeks before the CNY are quite similar between the treatment and control groups. However, for Chinese scholars, we find that the submission propensity first shifts up slightly one week before the CNY; then, there is a significant downward trend in the propensity during the CNY week, and the gap in the submission propensity between the Chinese and the non-Chinese decreases after the CNY week. Limited differences are detected two weeks post-CNY. The above pattern is more significant if we focus only on comparisons in 2020.

4. Empirical results

4.1. Discontinuity baseline: CNY effects

Table 2 shows the effects of the CNY on journal submissions and desk rejection rates. Columns (1) and (2) show the general holiday effect of the CNY on scholarly production. We find a significantly negative role of \(1(\text{CNY}) \ast 1(\text{Chinese})\), indicating that compared with scholars from other countries, Chinese scholars tend to have lower probabilities (85% of mean) of submitting papers to a peer-reviewed journal during the CNY vacation. We do not find a significant difference in the desk rejection rate in the CNY week between Chinese submitters and others.

In Columns (3) and (4), we further include the interactions of the pre-CNY and post-CNY effects. Focusing on the three interaction terms, we find a clear discontinuity pattern around the CNY week. Compared with scholars from other countries, the submission rate of the Chinese is increasing (by 78% of the mean) one week before the CNY vacation starts. During the CNY week, the submission rate drops significantly. Although the coefficients of \(1(\text{post-CNY}) \ast 1(\text{Chinese})\) and \(1(\text{CNY}) \ast 1(\text{Chinese})\) are both negative, our F test indicates a relatively steeper magnitude in the CNY week compared with one week after, indicating that the submission propensity drops during CNY (by 85% percent of mean) and recovers gradually post-CNY (by 60% percent of mean). In other words, Chinese scholars tend to accelerate the paper production process and deliver their new submissions to peer-reviewed journals before the CNY vacation; if they

\textbf{Notes:} This figure exhibits the robustness test in the Regression Discontinuity in terms of the distribution of new submissions (%) around the CNY week by Chinese submitters. The blue line is the 4th order global polynomial fit of the submission propensity for Chinese submitters. The red dot is the averaged submission propensity for Chinese submitters across each week. The vertical dash line indicates the CNY week while the x-axis denotes the week difference to CNY.
cannot, they will submit after the CNY week otherwise. This is further consistent with our regression discontinuity tests (Fig. 3) and marginsplot of the event study (Fig. 4). In terms of the unconditional desk rejection rates, we find a higher rejection rate of papers submitted one week before the CNY from Chinese scholars compared with submissions from scholars based in other countries; the rejection rate is slightly lower if the paper is submitted one week after the CNY week. This pattern could reflect the acceleration of completion before the CNY week. This pattern could reflect the abovementioned process in submission, as an acceleration of completion before the CNY might be associated with lower quality compared with those being further polished and submitted later and after the CNY. In general, there is a discontinuity pattern in the productivity of Chinese scholars induced by the holiday effect. Consequently, they tend to increase their journal submission propensities one week before the CNY; their submission propensity drops significantly during the CNY vacation and recovers gradually post-CNY, in association with the holiday effect.

Our findings are consistent with the literature suggesting that holidays such as the CNY pose significant holiday effects on economic activities (Ming, Zhou et al., 2020). As previous research primarily focuses on trading behaviors (such as stock market shutdowns) and production behaviors at fixed locations (such as factory shutdowns), we extend these studies with further evidence on the impact of academic behavior that requires communicating complex information and allows flexibility in deciding when, where and whether to work.

4.2. Productivity response to COVID-19

We then include the interaction of the DD term with the COVID-19 outbreak. Table 3 shows the effects of the outbreak on scholarly production in terms of journal submissions and desk rejection rates. The results in Column (1) exhibit the limited general effect of the outbreak on the quantity of new journal submissions by Chinese scholars in the CNY week. However, when turning to the quality of submission, we find that the unconditional desk rejection rate of Chinese submissions in the CNY week is likely to be higher. Columns (3) and (4) report the productivity response to COVID-19 after including the interaction of the pre- and post-CNY effects. We find that the outbreak significantly deepens the discontinuity pattern identified above and has a short-term negative impact on scholarly productivity in terms of both quantity and quality for Chinese scholars. Specifically, their submission pace is further accelerated due to the outbreak, representing a slower recovery rate post-CNY and a higher propensity of journal submissions pre-CNY, while their

Table 2

| VARIABLES | (1) Propensity to Submit (%) | (2) Propensity of Desk Rejection (%) | (3) Propensity to Submit (%) | (4) Propensity of Desk Rejection (%) |
|-----------|-----------------------------|-------------------------------------|-----------------------------|-------------------------------------|
| 1(CNY) * 1(Chinese) | -0.0821*** | 0.0201 | -0.0136 | 0.00834 |
| 1(preCNY) * 1(Chinese) | 0.0741*** | 0.00830 | 0.0125 | 0.00830 |
| 1(postCNY) * 1(Chinese) | 0.0186 | 0.00105 | 0.0150*** | 0.01005 |
| Observations | 3556,512 | 3556,512 | 3556,512 | 3556,512 |
| R-squared | 0.0201 | 0.00830 | 0.0200 | 0.00830 |
| Author Fixed Effects | YES | YES | YES | YES |
| Year-Month Fixed Effects | YES | YES | YES | YES |
| Author-by-Year-Month Fixed Effects | YES | YES | YES | YES |
| Mean of Y | 0.09548 | 0.02623 | 0.09548 | 0.02623 |

Notes: This table presents the regression results for the effects of CNY on scholarly productivity in terms of quantity and quality, based on the journal submission records collected from the online submission system. The dependent variable in columns (1) and (3) is the propensity of new submission (%) for each author. The dependent variable in columns (2) and (4) is the propensity of desk rejection (%) for each author. 1(Chinese) is a treatment dummy for Chinese scholars. 1(CNY) is an indicator equal to 1 if the submission is made during the CNY week each year. 1(preCNY) is a dummy variable that equals 1 if the submission is made one week before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made one week after the CNY week. Robust standard errors are clustered at the country level and reported in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

On the production side, productive activities that require on-site work in factories stop during this period, leading to a weakening of the intensity of productive activity across the country (Guo et al., 2018; Pei et al., 2020). Environmentally, the migration of people from the city to their rural hometowns and the stagnation of social production also set off a chain reaction of changes in anthropogenic emissions (Sun et al., 2020). On the transaction side, the stock market is closed during the holiday and trading volume is reduced. Research also found that returns after the CNY holiday are significantly higher than in other months (see Ahmad & Hussain, 2001 among others).
papers exert a higher propensity to be desk rejected under such circumstances, as a possible consequence of trading off the quantity and quality of productivities. COVID-19 might affect scholarly productivity through many potential channels, such as collaborative integration, workplace flexibility, or higher psychological tolls, such as stress and panic during the epidemic development. We provide further tests on these potential channels in Section 4.

### 4.3. Robustness checks

#### 4.3.1. Placebo tests

As time placebo tests, we examine whether there is a discontinuity pattern around an alternative and common festival (New Year) and in an alternative year. We then conduct a cross-sectional placebo test assigning scholars from the United States as the new treatment group.

Panels A1 and A2 of Table 4 report the results of the time placebo test; in Panel A1, we test the discontinuity pattern in submissions around the Christmas and New Year vacation (from December 24 to January 2), while in Panel A2, we move the shock to one year before and test its role on scholarly productivity. 1(Year2019) is a dummy variable that equals 1 if the submission is made one year before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made one week after the CNY week. 1(COVID) is a dummy variable that equals 1 if the submission is made after the outbreak of COVID-19. Robust standard errors are clustered at the country level and reported in parentheses. *** p < 0.01, *** p < 0.05, * p < 0.1.

#### 4.3.2. Confounding factors

##### 4.3.2.1. Distance to the last and new semesters

The CNY holiday effect could be interacted with the distance to the last or new semester. The timing of the new semester varies over the years, but it usually begins one or two weeks after the 7th day of the first lunar month (end of the CNY vacation). We further include the triple interaction term \( t(\text{lastSEM}) \times 1(\text{Chinese}) \times 1(\text{COVID}) \) and \( t(\text{newSEM}) \times 1(\text{Chinese}) \times 1(\text{COVID}) \) to control for the effect of the timing of the semesters, where \( t(\text{lastSEM}) \) is a discrete variable counting the time difference between the submission to the end of the last (fall) semester, while \( t(\text{newSEM}) \) is a discrete variable counting the time difference between the submission to the end of the next (spring) semester. In Table 5, we find consistent results in terms of the discontinuity and the productivity response to COVID-19. We also conclude the same patterns in the SSRN data.

#### 4.3.3. Cross validity test

As an alternative examination, we exploit the SSRN submission data. We restrict the SSRN sample to the "working paper series" and test the role of the CNY on Chinese scholars’ productivity. We focus on two proxies of productivity, i.e., the propensity to submit (%) and the (unconditional) propensity to revise (%). According to Table 6, we find that compared with other scholars, Chinese scholars exhibit a lower propensity to upload new working papers during the CNY week, which is similar to the results discovered in journal submissions. We also detect a discontinuity pattern in the propensity to submit and revise around the CNY week, although the effect is reversed: Chinese contributors tend to upload working papers one week post-CNY rather than pre-CNY, while the propensity to revise is consistently lower in the two-week window around the CNY vacation. Based on the discontinuity pattern we discovered with the SSRN submission data, we include the triple difference term to investigate the productivity response to COVID-19. Consistent with estimations from journal submissions, we find that the COVID-19 outbreak has a significant negative impact on scholarly productivity in terms of the propensity of new working paper uploads.

### 5. Potential channel discussion

In this section, we discuss the potential channels through which the COVID-19 outbreak might affect the scholarly production of journal and working papers in the short term. Based on the person–environment fit framework mentioned above, we primarily focus on the external factors of collaborative integration and work flexibility using COVID-19 mitigation policies as exogenous shocks and further the productivity response across different types of authorship (single authorship, coauthorship (with the same and different affiliation)). We further address the relative importance of psychological cost under the development of the outbreak, as compared with collaborative integration and work flexibility.
Here, we first compare the behavior difference between the single-authorship and coauthorship groups, which provides general evidence on the role of collaboration in scholarly productivity. We then focus on the coauthorship group and compare the difference between coauthors with the same affiliations and different affiliations to verify the transition channel of face-to-face interaction in affecting scholarly productivity.

Table 7 presents the regression results for the effects of the CNY and COVID-19 on sole authors and scholars with collaborations based on the journal submission records. We find that the triple interaction term (1(postCNY) * 1(Chinese) * 1(COVID)) is significantly negative for both single-authorship groups, indicating that productivity reduction from the outbreak is scarce for these scholars from both the quantity and quality perspectives. In addition, we also detect a significantly slower recovery of journal submissions in the coauthorship group, providing intuitive evidence that solitary virtual collaboration during the outbreak is not an efficient substitute for collaboration with richer media (Lee et al., 2011). We then verify this finding with a heterogeneity analysis of coauthorship with the same and different affiliations.

Table 8 provides evidence on the role of institutional proximity in scholarly productivity after the shock using data on the SSRN working paper series. Focusing on Columns (1) to (4), we find that the triple interaction term (1(postCNY) * 1(Chinese) * 1(COVID)) is significantly negative, indicating that the COVID-19 outbreak decreases Chinese scholars’ productivity in terms of new submissions of working papers after the CNY. For existing working papers, we do...
not find a significant role for the outbreak in reducing the propensity to revise. More importantly, we find a significant difference between the DDD coefficient in Columns (1) and (3) based on the T test, indicating that the negative effect of the outbreak on collaborations is deeper for coauthorship within the same institution than for coauthorship among different institutions. We then conduct a T test on the DDD coefficient in Columns (1) and (5) to show the role of collaboration in producing new working papers. We find that the magnitude of the negative effect of COVID-19 on scholarly productivity is larger for single authorship than for coauthorship within the same institution (and coauthorship among different institutions as well). This is consistent with our above findings on journal submissions.

The second potential channel is the change in workplace flexibility. To contain the spread of the virus, on February 5, the MOE required colleges and universities nationwide to offer online teaching and learning resources following the postponement of school semesters. Scholars affiliated with a university (which is the most common case) need to face different factors under this work-from-home (WFH) order in the educational system. The literature on workplace flexibility primarily focuses on industrial productivity, while the conclusions can be ambiguous. As the cohort-level variance in work flexibility is highly correlated with cross-sectional (firm-level or industry-level) characteristics and technology development, the mechanism of work flexibility is unclear due to the endogenous selection bias of adoption. Mitigating the endogeneity issue, Table 9 presents the heterogeneous regression results for the effects of the CNY and work-from-home order on scholarly productivity based on the journal submission records. The dependent variable in columns (1) and (3) is the propensity of new submission (%). The dependent variable in columns (2) and (4) is the propensity of desk rejection (%).

Notes: Controlling for the semester timing, this table presents the regression results for the effects of CNY and COVID-19 on scholarly productivity based on journal submission records. The dependent variable in columns (1) and (3) is the propensity of new submission (%). The dependent variable in columns (2) and (4) is the propensity of desk rejection (%). I(Chinese) is a treatment dummy for Chinese scholars. I(CNY) is an indicator equal to 1 if the submission is made during the CNY week each year. I(preCNY) is a dummy variable that equals 1 if the submission is made after the outbreak of COVID-19. I(lastSEM) is a discrete variable counting the time difference between the submission to the end of the last (fall) semester, while I(newSEM) is counting the time difference between the submission to the end of the next (spring) semester. Robust standard errors are clustered at the country level and reported in parentheses. ** p < 0.01, * * p < 0.05, * p < 0.1.

5.2. Remote work: workplace flexibility

The second potential channel is the change in workplace flexibility. To contain the spread of the virus, on February 5, the MOE required colleges and universities nationwide to offer online teaching and learning resources following the postponement of school semesters. Scholars affiliated with a university (which is the most common case) need to face different factors under this work-from-home (WFH) order in the educational system.

The literature on workplace flexibility primarily focuses on industrial productivity, while the conclusions can be ambiguous. As the cohort-level variance in work flexibility is highly correlated with cross-sectional (firm-level or industry-level) characteristics and technology development, the mechanism of work flexibility is unclear due to the endogenous selection bias of adoption. Mitigating the endogeneity issue, Table 9 presents the heterogeneous regression results for the effects of the CNY and work-from-home order on scholarly productivity based on the journal submission records collected from the online submission system. I(WFH) is a dummy variable that equals 1 if the submission is made after the first implementation of the work-from-home order in the education system. Focusing on the results in Columns (1) to (2), we find that the work-from-home order has a short-term negative effect on effectively substitute face-to-face meetings in knowledge production, which supports Hypothesis 1.
After eliminating the effects of collaborative integration, this effect could be triggered by the factors mentioned in the work-from-home experiment. From Columns (5)-(6), we find that the mitigation effect on productivity is more significant in the single-authorship group, which indicates that shifting work mode has a negative effect on the probability of producing papers during the CNY week each year. 1(preCNY) is a dummy variable that equals 1 if the submission is made one week before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made one week after the CNY week. 1(COVID) is a dummy variable that equals 1 if the submission is made after the outbreak of COVID-19. Robust standard errors are clustered at the country level and reported in parentheses. * ** p < 0.01, * * p < 0.05, * p < 0.1.

Notes: Panel A of this table presents the regression results for the effects of CNY on scholarly productivity in terms of quantity and quality, based on the SSRN submission records (working paper series). Panel B of this table presents the regression results for the effects of CNY on scholarly productivity in terms of quantity and quality, based on the SSRN submission records (working paper series). The dependent variable in columns (1) and (3) is the propensity of new submission (%) for each author. The dependent variable in columns (2) and (4) is the propensity of revision (%) for each author. 1(Chinese) is a treatment dummy for Chinese scholars. 1(CNY) is an indicator equal to 1 if the submission is made one week before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made one week after the CNY week. 1(COVID) is a dummy variable that equals 1 if the submission is made after the outbreak of COVID-19. Robust standard errors are clustered at the country level and reported in parentheses. * ** p < 0.01, * * p < 0.05, * p < 0.1.

### Table 6
Effects of CNY and COVID-19 on Scholar Productivity (SSRN Submissions).

| VARIABLES | Panel A: Discontinuity | Panel B: Respond to COVID-19 |
|-----------|------------------------|-----------------------------|
|           | Propensity to Submit (%) | Propensity to Revise (%) | Propensity to Submit (%) | Propensity to Revise (%) |
| 1(CNY) * 1(Chinese) | -0.109 ** ** (0.0170) | -0.00473 (0.00518) | -0.125 ** ** (0.0184) | -0.0047 (0.00522) |
| 1(preCNY) * 1(Chinese) | -0.213 ** ** (0.0487) | -0.0457 ** ** (0.00944) | 0.636 ** ** (0.0192 ** ** (0.00443) |
| 1(postCNY) * 1(Chinese) | 0.0636 ** ** (0.109) | -0.0192 ** ** (0.00443) | Observations | 1172.543 | 1172.543 | 1172.543 | 1172.543 |
| R-squared | 0.020 | 0.028 | 0.020 | 0.028 |
| Author Fixed Effects | YES | YES | YES | YES |
| Year-Month Fixed Effects | YES | YES | YES | YES |
| Author-by-Year-Month Fixed Effects | YES | YES | YES | YES |
| Mean of Y | 0.12743 | 0.02494 | 0.12743 | 0.02494 |
| Notes: Panel A of this table presents the regression results for the effects of CNY on scholarly productivity in terms of quantity and quality, based on the SSRN submission records (working paper series). Panel B of this table presents the regression results for the effects of CNY on scholarly productivity in terms of quantity and quality, based on the SSRN submission records (working paper series). The dependent variable in columns (1) and (3) is the propensity of new submission (%) for each author. The dependent variable in columns (2) and (4) is the propensity of revision (%) for each author. 1(Chinese) is a treatment dummy for Chinese scholars. 1(CNY) is an indicator equal to 1 if the submission is made one week before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made one week after the CNY week. 1(COVID) is a dummy variable that equals 1 if the submission is made after the outbreak of COVID-19. Robust standard errors are clustered at the country level and reported in parentheses. * ** p < 0.01, * * p < 0.05, * p < 0.1. |

### Table 7
Productivity Response to COVID-19 (Channel I: Collaborations; Journal Submissions).

| VARIABLES | Coauthorship | Single-Authorship |
|-----------|---------------|-------------------|
|           | Propensity to Submit (%) | Propensity to Revise (%) | Propensity to Submit (%) | Propensity to Revise (%) |
| 1(CNY) * 1(Chinese) | 0.176 ** ** (0.0610) | -0.0435 * (0.0232) | 0.729 ** ** (0.0770) | 0.539 ** ** (0.0667) |
| 1(preCNY) * 1(Chinese) * 1(COVID) | 0.0817 | -0.0370 (0.0220) | 0.0967 | 0.156 ** ** (0.0205) |
| 1(postCNY) * 1(Chinese) * 1(COVID) | -0.157 ** ** (0.0653) | -0.00520 (0.0421) | -0.179 ** ** (0.0522) | -0.0602 ** ** (0.0123) |
| Observations | 2774,232 | 2774,232 | 782,280 | 782,280 |
| R-squared | 0.009 | 0.009 | 0.010 | 0.010 |
| Author Fixed Effects | YES | YES | YES | YES |
| Year-Month Fixed Effects | YES | YES | YES | YES |
| Author-by-Year-Month Fixed Effects | YES | YES | YES | YES |
| Mean of Y | 0.06135 | 0.02581 | 0.2165 | 0.02773 |
| Notes: This table presents the heterogenous regression results for the effects of CNY and COVID-19 on scholars with collaborations and sole authors, based on the journal submission records collected from the online submission system. The dependent variable in columns (1) and (3) is the propensity of new submission (%) for each author. The dependent variable in columns (2) and (4) is the propensity of desk rejection (%) for each author. 1(Chinese) is a treatment dummy for Chinese scholars. 1(CNY) is an indicator equal to 1 if the submission is made during the CNY week each year. 1(preCNY) is a dummy variable that equals 1 if the submission is made one week before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made one week after the CNY week. 1(COVID) is a dummy variable that equals 1 if the submission is made after the outbreak of COVID-19. Robust standard errors are clustered at the country level and reported in parentheses. * ** p < 0.01, * * p < 0.05, * p < 0.1. |

The results show that scholarly productivity in terms of new journal submissions is significantly higher in single-authorship groups compared to coauthorship groups. This behavior is less likely to be affected by collaborative factors, as scholars' productivity is more significant in the single-authorship group after eliminating the effects of collaborative integration. This effect could be triggered by factors such as the trade-off of pros and cons in workplace flexibility. As a proxy for additional working efforts, we further employ two proxies, i.e., the propensity of a paper being submitted during off-hours (%) and the propensity of a paper being submitted during weekends (%). According to the results in Columns (3) to (4) and Columns (7) to (8), we find that the coefficient of the triple interaction term 1(preCNY) * 1(Chinese) * 1(WFH) is significantly negative for the single-authorship group, which indicates that eliminating the effects from collaborative integration, the shift in work mode has a negative effect on the probability of producing...
Table 8
Productivity Response to COVID-19 (Channel I: Collaborations; SSRN Submissions).

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------|-----|-----|-----|-----|-----|-----|
|           | Propensity to Submit (%) | Propensity to Revise (%) | Off-hours (%) | Weekday (%) | Propensity to Submit (%) | Propensity to Revise (%) | Off-hours (%) | Weekend (%) |
| 1(CNY) * 1(Chinese) * 1(COVID) | 0.0614 | 0.00709 | -0.306 *** | 0.0777 ** | 0.0970 | 0.0649 | 0.0777 ** | 0.0970 |
| 1(postCNY) * 1(Chinese) * 1(COVID) | -0.494 *** | 0.0705 ** | -0.133 | 0.0555 | -0.835 *** | 0.0817 | -0.835 *** | 0.0817 |
| Observations | 473.474 | 473.474 | 699.069 | 699.069 | 286.516 | 286.516 | 286.516 | 286.516 |
| R-squared | 0.019 | 0.028 | 0.021 | 0.013 | 0.018 | 0.031 | 0.018 | 0.031 |
| Author Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Year-Month Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Mean of Y | 0.1415 | 0.0263 | 0.1191 | 0.0264 | 0.1386 | 0.0219 | 0.1386 | 0.0219 |

Notes: This table presents the heterogeneous regression results for the effects of CNY and COVID-19 on scholars with collaborations and sole authors, based on the SSRN submission records (working paper series). The dependent variable in columns (1) (3) and (5) is the propensity of new submission (%), while the dependent variable in columns (2) (4) and (6) is the propensity of revision (%) for each author. 1(Chinese) is a treatment dummy for Chinese scholars. 1(CNY) is an indicator equal to 1 if the submission is made during the CNY week each year. 1(preCNY) is a dummy variable that equals 1 if the submission is made one week before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made one week after the CNY week. 1(WFH) is a dummy variable that equals 1 if the submission is made after the first implementation of the Work-from-Home order (which is January 26, 2020, in mainland China). Robust standard errors are clustered at the country level and reported in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

addition to additional working efforts. In line with Hypothesis 2, these detrimental effects are further supported by consistent results based on SSRN working paper submissions and revisions, which are shown in Table 10.

Based on rich measurements of quantity, quality, and time allocation, we find that WFH intervention has a short-term negative effect on scholarly productivity, which is consistent with boundary theory. Higher workplace flexibility alters physical and temporal boundaries and amplifies the negative effect on productivity through work–family conflict, schedule control, and self-discipline issues (Beauregard & Henry, 2009; Kelly et al., 2014; McCloskey & Igbria, 2003; Raghuram & Wiesenfeld, 2004). Hence, solitary remote work could deepen the negative effect of exogenous shocks on productivity through the abovementioned potential factors and technology frictions. However, the long-term effect of the shift in work mode could be ambiguous when people are motivated by self-correction and peer pressure.

5.3. Crisis related: psychological cost

The productivity response to the COVID-19 lockdown could be associated with some psychological factors, such as stress and panic during the epidemic development. We further use COVID-19 as an exogenous shock with dynamics in terms of treatment intensity, and identify the relative role of psychological costs such as stress and panic along with the epidemic development compared with channels of collaborative integration and workplace flexibility.

In Table 11, we test the correlation between the epidemic development and productivity outcomes using both journal and working paper submission data. The variable Cases is a continuous
Table 10
Productivity Response to COVID-19 (Channel II: Flexibilities; SSRN Submissions).

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) |
|-----------|-----|-----|-----|-----|-----|-----|
|           | Propensity to Submit (%) | Propensity to Revise (%) | Weekend (%) | Propensity to Submit (%) | Propensity to Revise (%) | Weekend (%) |
| 1(CNY) * 1(Chinese) * 1(WFH) | 0.333 *** (0.0653) | 0.0554 *** (0.00999) | 0.0370 *** (0.00108) | 0.218 *** (0.0270) | -0.00742 (0.00239) | 0.0305 *** (0.000508) |
| 1(postCNY) * 1(Chinese) * 1(WFH) | -0.905 ** (0.106) | 0.0466 (0.0124) | -0.0443 ** (0.00208) | -1.881 *** (0.126) | -0.0739 *** (0.0178) | -0.0482 ** (0.00324) |
| Observations | 1172,543 | 1172,543 | 1172,543 | 286,516 | 286,516 | 286,516 |
| R-squared | 0.020 | 0.028 | 0.001 | 0.018 | 0.031 | 0.001 |
| Author Fixed Effects | YES | YES | YES | YES | YES | YES |
| Year-Month Fixed Effects | YES | YES | YES | YES | YES | YES |
| Author-by-Year-Month Fixed Effects | YES | YES | YES | YES | YES | YES |

Notes: This table presents the heterogeneous regression results for the effects of CNY and Work-from-Home order on scholarly productivity, based on the SSRN submission records (working paper series). The dependent variable in columns (1) and (4) is the propensity of new submission (%) for each author. The dependent variable in columns (2) and (5) is the propensity of revision (%) for each author. The dependent variable in columns (3) and (6) is the propensity of a paper submitted or revised during weekends (6). 1(Chinese) is a treatment dummy for Chinese scholars. 1(CNY) is an indicator equal to 1 if the submission is made during the CNY week each year. 1(postCNY) is a dummy variable that equals 1 if the submission is made one week after the CNY week, while 1(preCNY) is a dummy variable that equals 1 if the submission is made one week before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made after the first implementation of the Work-from-Home order (which is January 26, 2020, in mainland China). Robust standard errors are clustered at the country level and reported in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.

proxy that equals the logarithm of the number of new cases in Columns (1), (3), (5) and (6), which equals the logarithm of the number of accumulated cases (in 1000) in Columns (3), (4), (7) and (8). We find a relatively weak effect of the triple interaction term (1(postCNY) * 1(Chinese) * Cases) using either measure. This is especially true when we focus on the behaviors of the single-authorship group, as the effect of collaborative integration is eliminated. In general, the role of psychological costs, such as stress and panic during epidemic development, is relatively limited compared with the channels of collaborative integration and workplace flexibility, which supports Hypothesis 3. In future research, with further data on scholars’ mental well-being measures, the mechanism of

Table 11
Productivity Response to COVID-19 (Channel III: Psychology).

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|-----------|-----|-----|-----|-----|-----|-----|-----|-----|
|           | Propensity to Submit (%) | Propensity of Desk Rejection (%) | Propensity to Submit (%) | Propensity of Desk Rejection (%) | Propensity to Submit (%) | Propensity to Revise (%) | Propensity to Submit (%) | Propensity to Revise (%) |
| Panel A: All Observations | Journal: New Cases | Journal: Cumulated Cases | SSRN: New Cases | SSRN: Cumulated Cases | Journal: New Cases | Journal: Cumulated Cases | SSRN: New Cases | SSRN: Cumulated Cases |
| 1(CNY) * 1(Chinese) * Cases | 0.0536 ** (0.0258) | 0.0198 ** (0.00918) | -0.0130 (0.0118) | -0.00184 (0.00162) | 0.0565 ** (0.0239) | 0.0210 (0.0132) | -0.0421 (0.0935) | 0.0491 *** (0.0116) |
| 1(preCNY) * 1(Chinese) * Cases | 0.0806 ** (0.0378) | 0.0597 ** (0.0114) | 0.0345 ** (0.00815) | 0.0553 (0.00589) | -0.0198 ** (0.00717) | 0.0059 ** (0.00255) | 0.0612 (0.0851) | 0.00550 (0.00550) |
| 1(postCNY) * 1(Chinese) * Cases | -0.121 ** (0.0473) | -0.00432 (0.00196) | -0.00240 (0.000196) | 0.02020 (0.000198) | -0.00109 (0.000532) | -0.00819 ** (0.000532) | -0.229 (0.0389) | 0.0389 *** (0.000532) |
| Observations | 3556,512 | 3556,512 | 3556,512 | 3556,512 | 1172,543 | 1172,543 | 1172,543 | 1172,543 |
| R-squared | 0.010 | 0.009 | 0.010 | 0.009 | 0.020 | 0.028 | 0.020 | 0.028 |
| Panel B: Single-Authorship | Journal: New Cases | Journal: Cumulated Cases | SSRN: New Cases | SSRN: Cumulated Cases | Journal: New Cases | Journal: Cumulated Cases | SSRN: New Cases | SSRN: Cumulated Cases |
| 1(CNY) * 1(Chinese) * Cases | 0.0260 ** (0.00015) | 0.00491 (0.00689) | 0.0571 (0.0535) | 0.121 *** (0.0718) | -0.0266 ** (0.0115) | 0.00542 (0.00331) | 0.146 ** (0.0658) | -0.0296 ** (0.0041) |
| 1(preCNY) * 1(Chinese) * Cases | -0.0133 (0.0121) | -0.00284 (0.020241) | 0.0531 ** (0.0257) | 0.0296 *** (0.0105) | 0.0402 (0.0316) | 0.0265 (0.0271) | 0.0147 (0.0742) | 0.0457 * (0.0239) |
| 1(postCNY) * 1(Chinese) * Cases | -0.00863 ** (0.00424) | -0.00204 * (0.000112) | -0.101 *** (0.0331) | -0.0112 (0.00954) | -0.0191 * (0.000998) | -0.00559 * (0.00107) | 0.135 (0.0135) | -0.262 * (0.0121) |
| Observations | 782,280 | 782,280 | 782,280 | 782,280 | 286,516 | 286,516 | 286,516 | 286,516 |
| R-squared | 0.010 | 0.010 | 0.010 | 0.010 | 0.018 | 0.031 | 0.018 | 0.031 |
| Author Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Year-Month Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |
| Author-by-Year-Month Fixed Effects | YES | YES | YES | YES | YES | YES | YES | YES |

Notes: This table presents the regression results for the effects of COVID-19 panic on scholarly productivity, based on the journal submission and the SSRN submission records. Dependent variables are propensities of new submission (%) and desk rejection (%). 1(Chinese) is a treatment dummy for Chinese scholars. 1(CNY) is an indicator equal to 1 if the submission is made during the CNY week each year. 1(preCNY) is a dummy variable that equals 1 if the submission is made one week before the CNY week, while 1(postCNY) is a dummy variable that equals 1 if the submission is made after the first implementation of the CNY week. The variable Cases equals the logarithm of the number of new cases in Columns (1), (2), (5), and (6), while equal to the logarithm of the number of accumulated cases (in 1000) in Columns (3), (4), (7) and (8). Robust standard errors are clustered at the country level and reported in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1.
psychological costs could be more explicitly explored based on the identification of psychological boundaries in the long term.

6. Concluding remarks

In this paper, we exploit the natural experiment of the COVID-19 outbreak and its corresponding mitigation policies and investigate the roles of collaborative integration and work flexibility in scholarly productivity. Using data on the quantity and quality of the journal and working paper submissions, we have three streams of major findings. First, there is a discontinuity pattern in the productivity of Chinese scholars around the CNY, which indicates that Chinese scholars tend to increase their journal submission propensity one week before the CNY, while their submission propensity drops during the CNY and recovers gradually post-CNY. Second, COVID-19 has a negative impact on scholarly productivity in terms of quantity and quality post-CNY. The submission pace of Chinese scholars accelerated after the outbreak, representing a slower recovery post-CNY and a higher propensity of journal submission pre-CNY, while their papers showed a higher propensity to be rejected under such circumstances. Such short-term detrimental effect on scholarly productivity is induced mainly through the channel of collaborative integration and workplace flexibility due to mitigation policies in terms of social distancing and working from home. Specifically, virtual communication cannot effectively replace face-to-face meetings in knowledge production; higher workplace flexibility could strengthen the negative effect of exogenous shock productivity through potential factors such as self-discipline and technology frictions. The role of psychological costs, such as stress and panic during epidemic development, is relatively limited.

Scholarly productivity poses broad implications for enhancing the knowledge-based economy. However, in addition to personal characteristics, the role of external factors that affect research productivity is still ambiguous due to endogeneity challenges, especially under the rapid prevalence of virtual teams and remote work in the knowledge-intensive sector. Our paper primarily provides two theoretical contributions. First, regarding the collaboration channel, our paper is related to discussions on (scholarly) productivity and virtual teams facilitated by digital communication technology. Challenged by endogeneity concerns on collaboration integration and technology development, empirical studies have debatable remarks on whether electronic communication may be a strong substitute for face-to-face meetings (Agrawal & Goldfarb, 2008; Lee et al., 2011; Vasilieadou & Vliegenthart, 2009; Bayrak, 2012). In this paper, we use mitigation measures amid the COVID-19 outbreak as a valid exogenous shock to test the role of intellectual collaboration and the difference between virtual and interpersonal communication in collaborative integration, which addresses endogeneity between collaboration integration and technology development (Hamermesh & Oster, 2002). Our findings on the scholarly productivity of the treatment group and the significant heterogeneity between the single-authorship and coauthorship groups inform the role of collaboration and collective communication modes in promoting productivity.

Second, regarding the work environment channel, our discussion builds on the literature focusing on productivity and remote work associated with a higher degree of time and location flexibility. Current studies highlight the effectiveness and boundary cost of the WFH practice in sectors with direct supervision at the workplace (Bloom et al., 2015; Konrad & Mangel, 2000; Kelly et al., 2014; Shamir & Salomon, 1985; McCloskey & Igbina, 2003; Raghuram & Wiesenfeld, 2004; Beauregard & Henry, 2009; Choudhury et al., 2020), while there are still debates on how work flexibility influences productivity (Bailey & Kurland, 2002), especially in the academic field. As an extension, we investigate the role of workplace flexibility and boundaries in the academic sector, exploiting the natural experiment of the WFH mitigation policy during the COVID-19 outbreak. We also provide evidence on the relative importance of mental tolls in an environment with severe risks and uncertainties (Brooks et al., 2020; Strong, 1990).

Our paper also provides practical implications. The productivity measurement and quantitative findings of this research foster understanding of the underlying mechanisms of pandemic effects on the knowledge production process in terms of both quantity and quality, which contributes to the scientific community in terms of how to improve productivity in the digital era and during a massive crisis. Specifically, the proprietary data used in this study reveal information on submissions/desk rejections instead of final publications/patents (see Hoekman et al. (2008), among others), which enables both the quantity and quality measures of scholarly productivity, eliminates impacts from the referee side, and mitigates conditional and selection bias in gauging the effect on productivity. The findings in this paper highlight that while advances in virtual communication technologies can facilitate productivity by lowering collaboration costs, they currently cannot be a perfect substitute for face-to-face communication in collaborative integration due to a lack of media richness. Moreover, the academic sector relies mainly on self-control instead of direct supervision. Hence, a solitary adoption of WFH induces negative effects on productivity in terms of quantity and quality. Meanwhile, we contribute to the measurement of the broad impacts of COVID-19 apart from consumption, business operations, public health, demographics, and capital markets (Atkeson, 2020). Our study focusing on high-skilled productivity could shed light on the role of the COVID-19 outbreak in the knowledge production process. As scholarly productivity is independent of the dynamics of the supply and demand sides in the general economy, our study could mitigate the confounding factors and provide a clean estimation. Our results also suggest the cost of mitigation policies by investigating how the pandemic and remote working under mitigation policies affect scholarly output, which is critical for policymakers to evaluate and smooth the broad impact of a health crisis with more efficient measures.

Declaration of Competing Interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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