Full length article

Does COVID-19 make the firms' performance worse? Evidence from the Chinese listed companies[☆]

Dongyang Zhang [a], Wenping Zheng [b],*

[a] Capital University of Economics and Business, China
[b] University of International Business and Economics, China

A B S T R A C T

The influence of pandemics is still a black box, and the mechanism is attracting the attention of policymakers and scholars to guide the policy design in the aftermath of Covid-19 pandemics. This paper takes an in-depth look at the performance impact of pandemics from the perspective of operation, which is essential in a comprehensive evaluation of the economic effects of pandemics. With the help of novel quarterly data of Chinese listed firms from 2019 Q1 to 2021 Q2, we find that the Covid-19 decreases the sale-related profitability. For the mechanism, this paper finds that the pandemics make the operation longer, increase the cost, and reduce the potential cash flows. In addition, the environmental tax can significantly weaken the adverse shocks. The policy implication is that the sale boosting or consumption stimulus is vital in economic recovery, and the governments should efficiently use the positive effect of environmental tax.

1. Introduction

COVID-19 is now a dominant risk factor of the global economy. The fast spread of that kind of pandemics makes most governments adopt lockdown policies and keep social distance to prevent the increasing cases (Fairlie and Fossen, 2021; Kong and Prinz, 2020; Brodeur et al., 2021). In 2020, most countries experienced negative economic growth but optimistic in several nations, and China maintained 2.3%, which is the only one with positive change among major nations.[1] In that situation, the micro foundation of pandemic effect on micro-units is far from a convincing conclusion; at the same time, the economic recovery cannot be implemented without the participation of micro firms. Thus, the investigation on the micro effect of Covid-19 is in urgent need in the aftermath of a new stage of anti-Covid-19 pandemics.

Since the pandemic outbreak at the beginning of 2020, most policymakers have tried their best to know how does the Covid-19 affecting economic growth and stability; however, it is still be neglected that the economic influence under unexpected shocks is far from a clear answer. On one side, the uncertainty may increase innovation risk and shape the application space after utilization. On the other hand, the uncertain shock may alter the market structure, and some of them may be slumped with broken supply chains (Dana, 1999).

Table 1
Summary statistics.

	Mean	Std. Dev.	25%	50%	75%	95%	Max.
Covid	44.9	20.6	33	35	44	98	100
Age	21.9	5.47	18	22	25	29	69
Size	7.76	1.14	6.96	7.67	8.48	9.77	11.7
Leverage	0.41	0.19	0.26	0.41	0.55	0.74	0.99
equityshare10	0.59	0.14	0.48	0.59	0.69	0.82	0.95
equitycontrol	0.29	0.46	0	0	1	1	1
Tobin Q	1.87	1.37	1.15	1.45	2.01	4.31	23.9

In addition, for the impact of COVID-19, several studies have made attempts to check the potential innovation response (Caballero-Morales, 2021; Woolliscroft, 2020), investment portfolio (Yoshino et al., 2021; Zhang and Kong, 2022). Lee and Trimi (2021) discuss the innovation transformation in the aftermath of COVID-19, and emphasize the power of digitization. However, the direct effect of Covid-19 lacks sufficient empirical evidence, most of them only predict potential response to the recovery based on CGE or DSGE model or simulations (Can et al., 2021). This paper provides new evidence on the pandemic effect, especially with the listed firms in China. At the same time, A growing literature sheds light on the economic influence of the pandemics, especially the impact of the outside environment on firm-level innovation decisions has been extensively investigated in the recent literature. Kong and Prinz (2020) discuss the effect on employment, Coibion et al. (2020) turn on the economic cost of lockdown under the circumstance of pandemics. In addition, the impact of the outside environment on firm-level innovation decisions has been extensively investigated in the recent literature. Bigio et al. (2020) emphasize macroeconomic policy choice is essential for the recovery after the pandemics. (2021). However, the pandemic effect on operation activities and the role of the environmental tax are rarely exploited.

The contribution of this paper may be concluded into two aspects: First, this paper sheds light on the operational response to the Covid-19 related policies for listed firms. For the context of China, the Covid-19 policies have been widely proved efficient to reduce the negative effect of pandemics. We utilize the quarterly frequency data to observe the short response of listed firms. In addition, different from the financial performance of profit or sale, we focus on the operation indicators with a closer relationship to the supply chain. Second, we provide mechanism analysis on the relationship between Covid-19 and firms' performance. The channel on management-related cash cycle indeed contributes to the influence of Covid-19. In addition, we also examine the role of an environmental tax on the nexus between Covid-19 and performance, due to the introduction of that tax in the year 2018. And we observe a significant promotion role of environmental tax by technical upgrade incentive.

The remainder of this paper is organized as follows. Section 2 discusses the stylized facts, Section 3 provides a literature review of the hypothesis construction, Section 4 presents our methodology and describes the data, Section 5 shows baseline specification, the main empirical results and robustness tests, and the mechanisms. Section 6 concludes the paper and provides policy implications.

2. Stylized facts

In this section, we present those facts accompanied by the COVID-19 pandemics for listed firms.

The influence of outside shock largely depends on the geographic distribution in most cases. In this paper, the stylized characteristics of Covid-19 may decide the impact degree on the performance of listed firms. On the one hand, it can be easily observed that those firms are distributed unequally in geography. Those firms located in Guangdong, Zhejiang, and Jiangsu provinces account for a fraction of 16.16%, 11.79%, and 11.61%, respectively (Fig. 1). On the other, similarly, the Covid-19 cases also distributed heavily in Hubei provinces, which accounts for almost 80% at the end of 2020 (Fig. 2). For those firms located in western areas, the small number of cases indicates the shorter period under production slump and fast recovery.

Under the unexpected shock of pandemics, the direct prevention strategy but with the highest efficiency to the spread of pandemics is lockdown and social distancing policies, widely applied in most countries in 2020. Several studies also prove the deduction effect in preventing from infection of pandemics (Cauchemez et al., 2020). However, this policy is also accompanied by high cost, especially in manufacturing and services, due to the necessary face-to-face contact in the work process (Kang et al., 2020; Goolsbee and Syverson, 2020; Lourenço and Rua, 2021). Thus, the effect of pandemics should make the invention of lockdown likely policies. In Table 2, we find a remarkable decrease in operating income growth rate and rapid recovery since the second quarter, 2020. In addition, we use the quarterly data of financial reporting by listed firms to show the economic effect of COVID-19 pandemics in China. One direct feature of such a public event is the inventory response and account receivable indicators. Figs. 3–5 show the inventory cycle has been replicated in 2018 and 2019 within four quarters. However, we observe the rapid growth of inventory turnover days (either in the form of average term or the range term) in the first quarter. With longer turnover days, the inventory cycle may be slower with a higher cost of operations. When we turn to the term of account receivable, it can be easily found that the sharp hike of turnover days in the first quarter in the year 2020 (Fig. 3).

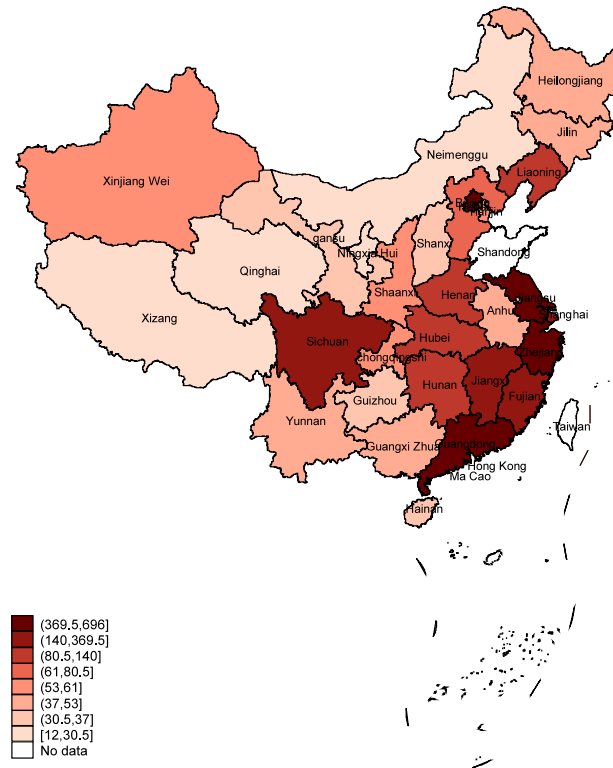## Geographic distribution of listed firms in China

Fig. 1. Geographic distribution of listed firms in China. Note: The sample is restricted within firms with IPO before the end of 2020. In addition, we use the real operation or control headquarters located province to replace the registration place for those firms with oversea registration. The data source is CSMAR database.

Table 2
The effect of Covid-19 pandemics on profit: subsample of manufacturing.

	(1)	(2)	(3)
Dependent variable	Operating income growth rate	Return on equity	Net profit margin on sales
Covid	−0.3459**	−0.0161	−0.1119***
	(−2.10)	(−0.79)	(−2.87)
Age	−0.3179***	−0.0369	−0.1046**
	(−2.72)	(−1.64)	(−2.35)
Size	1.8634***	0.8659***	2.2881***
	(2.96)	(8.73)	(8.34)
Leverage	10.3645***	−5.1583***	−25.9875***
	(2.66)	(−6.68)	(−13.27)
equityshare10	8.0461*	3.5960***	12.5695***
	(1.89)	(6.32)	(6.55)
equitycontrol	−1.4573	−0.1541	−1.4645**
	(−1.02)	(−0.82)	(−2.45)
Tobin	2.5954***	0.4567***	1.4898***
	(4.13)	(6.65)	(6.63)
Constant	10.9034	−5.8419**	−4.6980
	(0.55)	(−2.54)	(−1.11)
FEs	Yes	Yes	Yes
Observations	4538	4528	4449
R-squared	0.0805	0.1314	0.1706

Note: Robust t-statistics in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
The FEs contain industry, province, and timely fixed effects.
The Operating income growth rate is compared with the same period of last year.

Covid-19 cases distribution in China
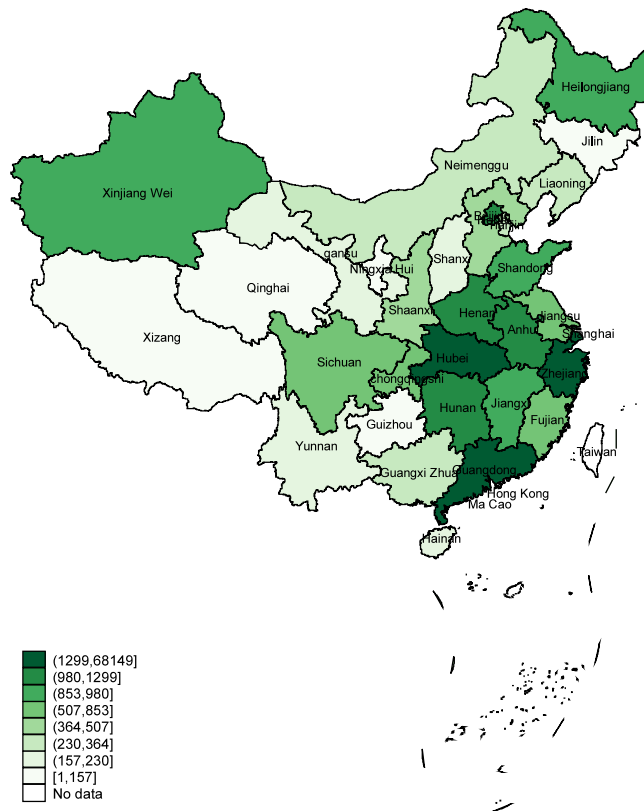
Fig. 2. The geographic distribution of Covid-19 cases in China. Note: We use the cumulative Covid-19 cases at the end of 2020. The data source is the National Health Commission of the People's Republic of China.
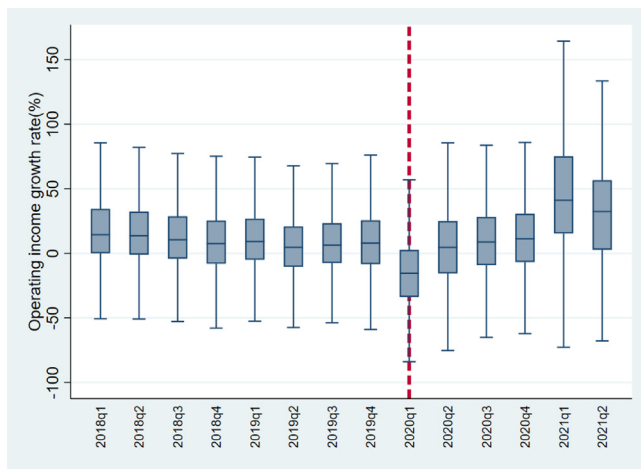
Fig. 3. Dynamics of Operating income growth rate during the COVID-19 pandemics.

3. Literature review and hypothesis development

Firm performance is widely recognized as the main interest of firms, researchers and policymakers in theoretical and empirical analysis, as it plays a vital role in industrial upgrading and economic growth in the long term. Evidence has

Fig. 4. Dynamics of inventory turnover days during the COVID-19 pandemics.

Fig. 5. Dynamics of account receivable turnover days during the COVID-19 pandemics.

well demonstrated that uncertainty is one of the main reasons that curb firm performance, among those uncertainties, the recent COVID-19 pandemic outbreak has resulted in considerable uncertainty in the economy (Zhang et al., 2020; Zhang, 2021). The COVID-19 pandemic, performing as a truly exogenous shock, has directly conducted an unexpected and massive influence on the financial market (Bing and Ma, 2021). Meanwhile, the ext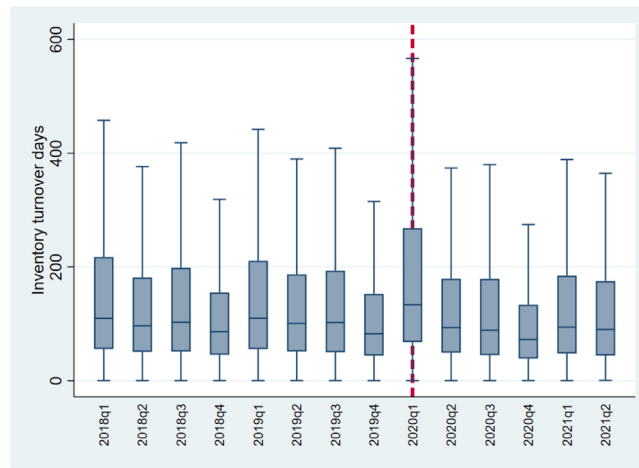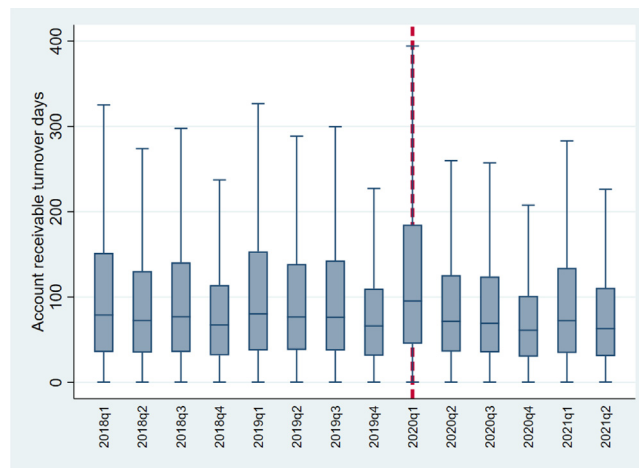ant literature has provided that external investors change their investment decisions when facing an unprecedented crisis (Hood et al., 2013; Del Giudice and Paltrinieri, 2017). Investors and financial markets are suffering from high degrees of uncertainty regarding financing physical and financial projects (Baek et al., 2020). Regarding this perspective, existing evidence has well examined the impact of COVID-19 on financial market performance, including stock market returns (Al-Awadhi et al., 2020; Ashraf, 2020; Phan and Narayan, 2020) and volatility (Zhang et al., 2020; Sharif et al., 2020; Kartal et al., 2020), and some consistent conclusions are drawn from existing empirical evidence that firms' financial performance is worsening due to the COVID-19 pandemic. As a result, firms are more likely to be financially constrained caused by the COVID-19 pandemic. According to the fundamental understanding of financial constraints raised by FHP (Fazzari et al., 1988; Zhang, 2022), firms' investment should be functional of the value gained by the potential investment opportunities and independent with firms' financial status when the financial market is unconstrained. On the contrary, firms have to select fewer investment projects and fully consider the potential benefit when firms are suffering from financial constraints; and well choose the investment projects under the trade-off concept of return versus risk (Erel et al., 2015). The existing financial constraints measurements and theories have consistently agreed that financial constraints can significantly curt firms' investment behaviors, such as ICFS (Fazzari et al., 1988); KZ (Kaplan and Zingales, 1997); WW (Whited and Wu, 2006) and SA (Hadlock and Pierce, 2010). Therefore, motivated by this literature, the present works focus on downside risk and uncertainty during the COVID-19 pandemic, they have shown that the stock market crash risk and investor sentiment in

China significantly lead the financial constraints to firms (Liu et al., 2021). Accordingly, we can predict that Chinese firms, suffering from financial constraints caused by the COVID-19 pandemic, decrease investment behaviors.

We raise our **hypothesis 1**: *Firms are more likely to decrease their in- vestment after the COVID-19.*

Firms' financial constraints play a vital role in trade credit assessment and asset liquidity management (Zhang and Liu, 2017). Due to the comparative advantages of credit rating commercial institutions in the evaluation and control of credit risk (Emery, 1984), trade credit (e.g., an account of payable) allows firms more access to financing resources, and it is more likely to be used to alleviate financial constraints (Zhang and Liu, 2017; Hoang et al., 2019). Further findings also indicate that firms choose less use trade credit when they have enough internal financings (Campello et al., 2011). In addition, asset and liquidity management are also proxied as the quality of solving financial constraints and improving the financial environment in existing studies (Zhang and Liu, 2017). Managerial in asset allocation and liquidity (i.e., operating assets turnover) may truly show firms' actual underlying economic performance inside. Therefore, management in liquidity allows managers to finance investment activities that maximize their profits. Thus, financially constrained firms increase the need for trade credit and liquidity, and the strong demand for these resources results in the delay of receiving trade credit and decreases the asset turnover ratio.

We then raise our **hypothesis 2**: *Firms are more likely to extend the repayment period using trade credit and managing asset turnover ratio.*

Fiscal policy is vital in impacting firm performance in the post-COVID-19 era (Zhang, 2021). In particular, a potential variation impact exists in volatility across industries. Better performance in the environment or environmentally friendly firms exhibit lower financial market re- turn volatility (Albuquerque et al., 2020; Haroon and Rizvi, 2020). Primarily, they have identified that highly energy-consumed firms are greatly challenged, and fiscal support policy targeting the recovery in the post-COVID-19 can significantly improve low energy consumed firms' performance, such as ROA, ROE, and Tobin's Q (Zhang, 2021). Glossner et al. (2020) further find the institutional environment worsens the effects of the COVID-19 market uncertainty by overusing the liquidity. Conversely, green recovery or sustainable growth requirements provide extra pressure to the firms and make them suffer a high level of uncertainty. Therefore, the tax of environmental protection adds the financial cost and liquidity requirement of firms in the post-COVID-19, and the policy effect might strengthen the negative impact on firm performance.

We here raise our **hypothesis 3**: *Firms are more likely to suffer from other policy interventions, which makes those firms have less impact than expected.*

4. Data and model specification

4.1. Theoretical background

In traditional econometric design, most studies may evaluate the economic effects induced by outside shock or unexpected shock by using a fixed-effect model, but the omitted variables problem may not be addressed due to unobservables, thus a difference-in-difference model is needed to exclude the potential bias stemming from omitted variables. In this framework, we assume one group faces the shock, but the other without shock. Under the condition of parallel trend, the exogenous shock may only alter the performance of the treatment group, but the performance of the control group maintains the continuous pattern (Abadie, 2010). If we define the performance gap of the treated group as Δ a between the periods of before and after the shock, and the gap of the control group as Δb, and then, the $\Delta = \Delta$a $- \Delta$b would like to be the pure effect of the outside shock. In this paper, the exposure of Covid-19 shock is unequally distributed among provinces in China, as the length of the restricted period varies due to the geographic distribution of Covid-19 cases. Considering that, we design the dynamic difference-in-difference model to exploit the causal effect of Covid-19 on firms' operation performance.

4.2. Identification

To estimate the causal effect of COVID-19 pandemics on the operation performance of listed firms, we design the identification strategy as follows:

$$Perform_{ijkt} = \alpha + \beta * covid_{jt} + X'\Gamma + \mu_j + \mu_k + \mu_t + \varepsilon_{ijkt} \tag{1}$$

where *Perform* represents firm-level performance indicators, which are measured by short-term operation indicators, such as operating income growth rate, return on equity, and net profit margins on sales, in baseline regressions. The subscripts i, t indicate firm and year, respectively. *covid* is the key independent variable, which measures the dynamic exposure to covid-19 pandemics for each province, which serves as the function of the interaction of treatment group and shock time in the static difference-in-difference model (Liu and Qiu, 2016). *X* is the control variable set, including age, size, leverage, equity share concentration, state control status, Tobin Q. For the choices of control variables, the reasons may be concluded in following:

(1) The age of firms, which is calculated by the gap between the observing year and the registration year plus 1. In most previous studies, the older firms may face higher operation costs, a fatter governance structure, weaker comparative advantage, and lower profitability (Coad et al., 2018). They may show a worse response to the outside shock in those cases.

(2) The size of firms is measured by the number of employees. Taking the size heterogeneity into account, we employ the logarithm of the number of employees to avoid potential estimation bias. For the listed firms, the larger size may bring economies of scale and show more substantial market power, and also more attractive to potential investors in the stock market (Alabdullah et al., 2018).

(3) The debt risk of firms is proxied by the leverage of firms and measured by the ratio of total debt to the total asset in this paper. To our knowledge, the influence of leverage on firms' performance is mixed with rich empirical evidence. The higher expected return may bring a positive relationship, while the agency problem may induce negative nexus (Ibhagui and Olokoyo, 2018).

(4) equity share concentration is calculated by the equity share of the top 10 shareholders. In previous studies, the heterogeneous concentration degree of ownership may alter the operation behaviors either for listed firms or private firms (Wruck, 1989). In some cases, the higher concentration may relate the decision efficiency, corporate governance, and so forth (Wang et al., 2021).

(5) state control status, which is measured by the dummy variable based on the status of control equity, if the controlling equity belongs to state-owned ownership, then we make it a value of 1; otherwise, the value of 0. This variable is widely verified that the state-owned ownership may behave differently from private ownership, mainly due to the stronger connection to the government and financial system (Cornett et al., 2010).

(6) Tobin Q is widely used to present the value of firms or reflect future profitability and is usually calculated by the ratio of market value to the cost of reproduction (Jayachandran et al., 2013). The bigger value of a firm, the larger space in operation performance it may have to respond to outside shock or competition (Wernerfelt and Montgomery, 2005).

In addition, we also control province, industry, and year fixed effects, μ_j, μ_k, and μ_t. The inclusion of those fixed effects can solve the problems of omitted variables or unobservable factors. The random error term ε_{ijkt} follows a normal distribution.

4.3. Data

The main data source is the listed firms in the CSMAR database, which is widely used in most issues of corporate finance in China (Kato and Long, 2006; Fu and Shen, 2020; Kaviani et al., 2020).[2] First, we obtain detailed quarterly records of profit sheets and financial indicators in the CSMAR database. In addition, we complementary this data with the RESSET database on indicators of detailed environmental tax details. Furthermore, we calculate the pandemic exposure with handle collected data from the website of provincial Health Commissions.

4.4. Descriptions

The main characteristics of critical variables used in this paper are shown in Table 1. We can easily observe that, the average exposure to covid-19 with strict restriction is 44.9 days. And for other controls, the summary figure shows a high degree of heterogeneity among those firms.

5. Empirical evidence

5.1. Baseline results

Table 2 shows the estimation results of Eq. (1). It presents the effect of pandemics on firms' profit using the two-way fixed effects model. The significance of the estimated effects is assessed using heteroscedasticity robust standard errors. For the firm-level profit indicators, we choose the operating income growth rate, return on equity, and net profit margins on sales as the proxies. For the first, it is closely related to the profit stemming from sales, the operation income acts as the majority of total revenue for most firms. As for the second, it measures the profit efficiency by the own capital itself, which puts more weight on the capital usage Alternatively, the third concentrates on the profit directly contributed by sales.

After controlling the firm-level characteristics and various fixed effects, we observe that the more prolonged exposure by Covid-19, the lower-income growth rate and profit margins will be received by those firms (Table 2). At the same time, the profit on capital does not respond significantly. Those two conflicting results imply that, the Covid-19 induced shock is easier to affect the operation activity than the investment behaviors, since the latter can be adjusted by investment portfolio.

In addition, when we turn to the control variables, it shows the following results. First, the old firms tend to have lower profit capability, especially in terms of operation activities, which is consistent with previous literature (Coad et al., 2013; Ilaboya et al., 2016). Second, the firms' size is favorable to the profit capability. Thus, more prominent firms may be affected less than smaller firms, due to self-adjustment and strong market power (Doğan, 2013). Third, the concentration

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[2] More related publications can be found in the website of CSMAR, https://www.gtarsc.com/.

Table 3
The effect of Covid-19 pandemics on the operation performance with subsample of manufacturing sector.

Dependent variable	(1) Operation cycle	(2) Inventory turnover ratio	(3) Inventory turnover days	(4) Accounts receivable turnover ratio
Covid	2.2897***	−0.0057***	1.5765***	0.0154
	(3.49)	(−2.86)	(2.76)	(0.80)
Age	−0.2536	0.0065*	−0.2960	−0.0431
	(−0.49)	(1.75)	(−0.79)	(−0.99)
Size	−25.1237***	−0.0286	−8.6343***	1.3915***
	(−6.23)	(−0.86)	(−3.26)	(3.82)
Leverage	114.9515***	−0.0517	46.2138***	−4.1436**
	(5.29)	(−0.35)	(3.09)	(−2.19)
equityshare10	−44.9638**	0.2902**	−10.3516	4.5125**
	(−2.36)	(2.15)	(−0.69)	(2.36)
equitycontrol	−23.5533***	0.2508***	−5.2352	3.9003***
	(−3.43)	(4.21)	(−0.99)	(4.93)
Tobin	9.0184***	−0.0241	10.0877***	0.3874
	(3.19)	(−1.59)	(3.98)	(1.59)
Constant	574.8537***	0.5317*	433.9497**	−15.0842***
	(3.49)	(1.86)	(2.55)	(−4.24)
FEs	Yes	Yes	Yes	Yes
Observations	3743	3754	3747	3704
R-squared	0.2740	0.1992	0.2927	0.2171

Note: Robust t-statistics in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
The FEs contain industry, province, and timely fixed effects.

of top 10 equity share and the Tobin q is in positive correlation with the profit capability, which may be induced by the stronger management capability or the strategic planning ability, and the pioneering market expectation (Salinger, 1984; Chen et al., 2005). Fourth, the leverage is only increased along with the operating income growth, but negative with the ROE and profit margin on sale, implying the dynamic correlation between leverage and the profit.

5.2. Robustness check

Since the sample of listed firms contains manufacturing and service sectors, but the operation model is different, the manufacturing firms may be more sensitive to the supply chain or the stable transportation between the factory and custom. For that sake, we limit the sample within the manufacturing sector in Table 3.

Comparing with the pandemics' effect in Table 2, on one side, we find the growth in operation cycle and inventory turnover days is larger, which indicates that the longer restrictive policy is employed, the worse the operation chain may transit to, and the recovery of manufacturing sector may need more efficient production cycle. On the other hand, we find a lower deduction on inventory turnover ratio and less growth in the manufacturing sector's accounts receivable turnover ratio. This may be due to the markup power and the key role of the scale of listed firms in specific industries. Since we know, the lower inventory turnover ratio means the higher inventory cost and less efficiency in the production value chain between upstream and downstream. Meanwhile, the account receivable turnover ratio is positive to the lack of cash flow, which is occasionally higher in the recession period. From those results, we can conclude that the manufacturing sector faces a lower pandemic shock than the service sector.

5.3. Mechanism of operation activity

As the results on the profit capability show that the sale-related activity is most likely to be affected in the short run under the threat of external pandemic uncertainty. We then choose the detailed operation-related performance indicators as the potential channel of sale profitability. In Table 4, we find that, the more prolonged exposure to Covid-induced abnormal business environment, those firms will respond with a more extended operation cycle, lower inventory turnover ratio, longer inventory turnover days, and higher account receivable turnover ratio. For those results, it can be concluded that the covid-induced lockdown indeed decreases the cash efficiency, makes the inventory turnover lower, and gives a higher probability of account receivable. Those three effects may uniformly cause the additional need for cash and the operation cost.

5.4. Channel of environmental tax

Even though we infer that the operation strategies may be the primary driver of pandemic shocks on the development of listed firms. The heterogeneity is apparent among industries and locations. To this end, environmental protection has been one of the major concerns for governments worldwide. Some studies discuss the role of pandemics on pollution during the Covid-19. On one side, the lockdown may bring lower efficiency in manufacturing production, the pollution

Table 4
The effect of Covid-19 pandemics on the operation performance.

Dependent variable	(1) Operation cycle	(2) Inventory turnover ratio	(3) Inventory turnover days	(4) Accounts receivable turnover ratio
Covid	1.8256***	−0.0065**	1.3140***	0.0576***
	(3.24)	(−2.35)	(2.62)	(2.99)
Age	−0.1090	0.0055	0.0066	−0.0580
	(−0.24)	(1.19)	(0.02)	(−1.57)
Size	−24.0901***	0.0134	−11.9951***	1.2280***
	(−6.95)	(0.40)	(−4.70)	(3.97)
Leverage	115.1576***	−0.0941	57.9466***	−3.2149*
	(5.56)	(−0.57)	(3.76)	(−1.89)
equityshare10	−39.6342**	0.3874**	−9.2220	3.3378*
	(−2.26)	(2.31)	(−0.66)	(1.95)
equitycontrol	−24.4772***	0.2477***	−5.2071	3.8057***
	(−3.90)	(3.80)	(−1.03)	(5.58)
Tobin	7.0275***	−0.0058	8.8979***	0.3126
	(2.74)	(−0.29)	(3.82)	(1.32)
Constant	215.6807***	0.6025	147.2010**	−1.6787
	(2.76)	(1.58)	(2.11)	(−0.40)
FEs	Yes	Yes	Yes	Yes
Observations	4547	4528	4528	4526
R-squared	0.3885	0.3884	0.4327	0.2351

Note: Robust t-statistics in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
The FEs contain industry, province, and timely fixed effects.

Table 5
The effect of Covid-19 pandemics on profit: Accelerator of environmental tax.

Dependent variable	(1) Operation cycle	(2) Inventory turnover ratio	(3) Inventory turnover days	(4) Accounts receivable turnover ratio
Covid	−0.7172	−0.0128**	−0.7517	0.0639***
	(−0.81)	(−2.05)	(−0.91)	(2.93)
covid ∗ environ tax	−830.6038***	5.8690**	−459.7956***	105.6974**
	(−4.19)	(2.40)	(−2.98)	(2.24)
Age	0.1710	−0.0015	0.2880	−0.0888**
	(0.37)	(−0.35)	(0.81)	(−2.54)
Size	−28.4465***	0.0907***	−16.0023***	1.6765***
	(−7.62)	(3.21)	(−5.98)	(5.75)
Leverage	123.9591***	−0.2977**	67.3348***	−4.8565***
	(5.80)	(−2.09)	(4.24)	(−3.28)
equityshare10	−46.2205***	0.5527***	−16.3884	3.9240**
	(−2.61)	(3.44)	(−1.17)	(2.32)
equitycontrol	−24.3607***	0.2017***	−5.1694	3.7041***
	(−3.82)	(3.32)	(−1.01)	(5.36)
Tobin	8.1316***	−0.0646***	9.9163***	0.1328
	(2.98)	(−4.00)	(3.95)	(0.58)
Constant	482.9631***	1.0858	361.7746***	−4.1891
	(4.95)	(1.62)	(4.09)	(−0.97)
FEs	Yes	Yes	Yes	Yes
Observations	4425	4404	4403	4405
R-squared	0.3789	0.4068	0.4199	0.2543

Note: Robust t-statistics in parentheses. ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.
The FEs contain industry, province, and timely fixed effects.

intensity decreases, and the environmental tax may not play a role in firms' performance. On the other, the negative shock may induce less stringency in environmental regulation, then the firms may pollute more for the need of economic recovery. We then investigate the role of environmental taxation in China. In this paper, due to the limitation of environmental tax, we calculate the environmental tax intensity by the ratio of environmental tax to the total asset in the quarter. Based on the baseline regression, we incorporate interaction term between Covid-19 and environmental tax, to observe the impact between higher environmental tax intensity and lower environmental tax intensity (Table 5). Different from the baseline mechanism results, we find that, first of all, the inventory turnover rate increases with the higher environmental tax intensity, and inventory turnover days decrease with higher environmental tax intensity. Secondly, the account receivable turnover ratio is much larger for those firms with higher environmental tax intensity. Third, the operation cycle decreases significantly for those firms with higher environmental tax intensity, but increases for the whole sample.

6. Conclusion and policy recommendation

Using newly merged financial data of listed firms in China, this paper exploits the effect of COVID-19 pandemics on firms' performance. With the help of a mechanism check to address the potential endogenous problems, we find that the pandemic shocks impact contributed mainly by the reduction of sale-related profit. We then use the mechanism check to prevent the products. In addition, we incorporate the role of environmental tax to exploit its effect on fading the shocks from pandemics.

The policy implication is straightforward that the recovery policies should put more weight on boosting the sales and reducing the trade credit. On the one side, encouragement of consumption and maintaining stable supply chains should be the key part of intervention policies, especially for developing countries. The main economic shock induced by the Covid-19 pandemics is lockdown and further supply chain disruption. During last year, most developed countries have adopted various policies to stimulate consumption, which mitigate the adverse effects of the recession. We can infer that consumption should combine with the supply chain actions to enlarge the stimulation effects. When the supply chain keeps disordered or turns disconnected, the mismatch between manufacturers and consumers would be larger, supply shortage may be the driver of unexpected inflation, which inhibits the demand recovery. At the same time, the regular operation may stable the inflation degree and contribute to employment recovery.

On the other, the structural allocation of taxation should be emphasized during the pandemics. The traditional wisdom supports the role of the automatic stabilizer of taxation, but this paper gives evidence on the promotion effect of supply chain operation for environmental tax. Given the macro background of the global carbon reduction target, the economic recovery should also make use of environmental taxation, to provide an incentive to the road of green development. Meanwhile, the green target would also inspire those firms to put more attention on technology upgrades and increase environmental investment.

Even though this paper gives new insights into the pandemics' influence, there are still essential questions at micro-level unanswered. Considering that, we organize the limitation in three aspects, which need future works to fill those gaps. First, this paper only sheds light on the aggregate level of operation performance, but without further analysis related to the structural change of operation strategy when suffering from the exogenous shock. In practice, the Covid-19 pandemic is now proved different from previous types of pandemics, the reaction of firms may also be different. The heterogeneous effects may catch further attention from the perspectives of business cycle, industrial characteristics, industrial value chain, and so forth. When the global production network is considered, we can also extend the analysis to the situation with supply chain volatility included. Second, this paper only examines the channel of environmental tax, but additional channels are in need of investigation to expand the picture of pandemics economics. A large body of previous literature provide evaluation of SARS pandemics, but most of them focus on the potential effects but not the mechanisms. For the Covid-19, the mechanisms are vital for the evaluation of policy validation and the potential alternative policies to overcome the economic recession induced by pandemics. Third, due to the limited data period from the outbreak of Covid-19 pandemics, we cannot provide long-run impact evaluation of the pandemics. However, the shock effect or policy impact may be long last or disappear soon, the long-run and dynamic effects evaluation would like to be more valuable and with higher policy implications for those interventions since the outbreak at the beginning of 2020.

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