Major Public Health Events And Enterprise Employment: A Difference In Difference Research Based on COVID-19

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Abstract. After the COVID-19 pandemic in 2020, many companies have struggled to make ends meet, fiscal deficits have become frequent, social unemployment rates have risen sharply, and economic growth has slowed down. The impact on companies and how policymakers can improve the difficulties in employment and slow economic growth have become hot social issues. This paper statistically analyzes employment data of different companies from 2017 to 2020, and establishes a difference-in-differences model based on this to reflect the impact of public health events on employment in companies. In combination with the actual situation in China, this paper fills the research gap and helps the government better formulate policy interventions for economic issues, stabilize society, and promote economic development.

Keywords: COVID-19 pandemic, employment situation in companies, difference-in-differences model

1 Introduction

Since the recorded history, the development of human society has been hindered by major public health events: the Black Death (plague) that prevailed in medieval Europe resulted in over 25 million deaths, greatly damaging the labor force and production at that time [7]; the Spanish flu in the early 19th century directly infected the majority of the world's population (1 billion out of 1.7 billion), with about 2.5% of the patients dying as a result. Many factories were forced to shut down, land became fallow, urban functions declined, and the labor force in Europe decreased significantly, causing a great impact on employment and economic development; the Ebola virus in Africa and the SARS outbreak in Asia in the early 21st century, followed by the COVID-19 pandemic that started in 2020, have all directly or indirectly caused a slowdown or even decline in social and economic growth by reducing labor force and affecting employment, with the COVID-19 pandemic in 2020 being the most severe [8]. The uniqueness of the COVID-19 pandemic is reflected in several aspects: long-term impact on physical functions, mainly manifested in the overall decline in the physical fitness of recov-

F. Cao et al. (eds.), *Proceedings of the 2023 5th International Conference on Economic Management and Cultural Industry (ICEMCI 2023)*, Advances in Economics, Business and Management Research 276,
https://doi.org/10.2991/978-94-6463-368-9_50

ered individuals, which partially reduces the productivity of workers; widespread transmission, as of March 2023, over 95% of Chinese citizens have been infected with COVID-19; strict control measures, such as nucleic acid testing and health code system during the pandemic, 14-day quarantine for regional travel, work-from-home measures for infected individuals, etc., have occupied a large amount of time and public resources, directly reducing the production efficiency of companies, increasing production costs, and further leading to employee layoffs to cut costs [2]. This paper takes the changes in employment in companies under the influence of the COVID-19 virus as the starting point and establishes a difference-in-differences model to assist in analyzing the impact of such major public health events on economic development and corporate operations.

In addition, major public health events also have significant impacts on individual workers. Taking the example of COVID-19, it is generally believed that adults who have been infected with COVID-19 may experience significant physical decline, and some individuals may also exhibit various respiratory diseases. At the same time, workers who are infected in the early stages of the disease may experience a significant decrease in work efficiency due to physical discomfort and other reasons, especially for manual laborers, which undoubtedly poses a huge blow to them [6]. For society as a whole, rising unemployment rates mean a decrease in people's living standards [5]. Therefore, from any perspective, such impacts are not positive events.

Out of curiosity about the above phenomena and the need to mitigate the aforementioned impacts, this study is based on data collected during the COVID-19 pandemic, and summarizes and studies the employment situation of enterprises by establishing a difference-in-difference model, inferring the impact of major public health events on employment in enterprises, and providing assistance for policy making.

This study collected financial and employment data of enterprises from the first quarter of 2017 to the fourth quarter of 2020, and used a difference-in-difference model to study the impact of the COVID-19 pandemic on employment in enterprises. In the model, we used the enterprises from the first quarter of 2017 to the fourth quarter of 2018 as the control group, and the enterprises from the first quarter of 2019 to the fourth quarter of 2020 as the experimental group. The study found that the employment situation in private enterprises changed more significantly than that in state-owned enterprises during the COVID-19 pandemic; the changes in eastern enterprises were larger than those in central and western enterprises; the impact on small and medium-sized enterprises was greater than that on large enterprises; and the impact on non-manufacturing enterprises was greater than that on manufacturing enterprises [3]

The marginal contributions of this article are as follows: Firstly, this article summarizes the research on the impact of public health events on employment in recent years, using the COVID-19 pandemic as a starting point. The double-difference method is used to visually demonstrate the impact of public health events on employment, which can help the government better predict the impact of such events on social employment and formulate more scientific policies. Secondly, unlike studies in other countries, we analyze the data from China, which is more in line with the actual situation and has a larger sample size. This helps provide more reliable and comprehensive research conclusions and provides reference for the Chinese government to formulate policies that

are tailored to the country's situation. Thirdly, we have come to a novel conclusion that the reduction in employment due to public health events is mainly reflected in small and medium-sized private non-manufacturing enterprises in economically developed regions. This provides important economic policy references for relevant departments to take more targeted measures to support these enterprises and mitigate the impact of public health events on them. Lastly, the structure of the article is well-organized, including sections on research design, empirical results, and conclusions and policy recommendations, which helps readers better understand the overall framework and conclusions of the research. This improves the readability and practicality of the research findings.

2 Research Design

When investigating the impact of major public health events on enterprises, most studies have used a difference-in-differences (DID) model to compare changes before and after the shocks. In this study, taking the employment situation of large enterprises as an example, we illustrate the changes in employment forms and attempt to calculate their costs under the impact of the COVID-19 pandemic, in order to determine the magnitude of the impact on employment.

2.1 Data Source and Processing

To accurately reflect the impact of major public health events on enterprise employment, this study mainly uses two types of data: employment data (including employment situation and employment scale) and financial data (mainly focused on income statements, balance sheets, and cash flow statements of enterprises). The employment data used in this study is sourced from Wind, and the financial data is sourced from CSMAR. The data period is quarterly data from the first quarter of 2017 to the fourth quarter of 2020. In accordance with the "2012 Industry Classification Guideline" of the China Securities Regulatory Commission, financial industries including monetary financial services (J66), capital market services (J67), insurance (J68), and other financial industries (J69) are excluded from the data. To mitigate the impact of extreme values of continuous variables on the overall data, this study adopts a winsorizing approach with a 1% two-sided trim. After the data processing mentioned above, this study obtained 3873 enterprises as the analysis sample.

2.2 Identification Strategy

The passage is discussing the estimation of the impact of the COVID-19 pandemic on employment in enterprises using a double-difference model. In terms of dividing control and treatment groups, the assumption is that there may be certain patterns in employment situation of enterprises between quarters. As enterprises did not experience the impact of the pandemic in the fourth quarter of 2017 but did experience it in the fourth quarter of 2019, the enterprises from the first quarter of 2017 to the fourth quarter

of 2018 are taken as the control group, and the enterprises from the first quarter of 2019 to the fourth quarter of 2020 are taken as the treatment group. In terms of shock timing, the start time for each group of enterprises is assigned a value of 1, the end time is assigned a value of 8, and the shock timing is assigned a value of 4, which represents the fourth quarter of the first year (for example, the first quarter of 2017 is assigned a value of 1, and the fourth quarter is assigned a value of 4) based on the above assumption.

With the above assumptions as a premise, the following model is constructed first:

$$lnem_{i,t} = \beta_0 + \beta_1 \times Post_t + \beta_2 \times Treat_i + \beta_3 \times Post_t \times Treat_i + \epsilon_{it} \quad (1)$$

In the model, the subscript i represents the enterprise, t represents time, with a total of 8 periods; Lnem represents the natural logarithm of the total number of employees, used to reflect the total number of employees; post indicates the shock timing, if the time is after the fourth quarter, it is assigned a value of 1, otherwise 0; treat represents the treatment and control groups, with a value of 1 for the treatment group and 0 for the control group; ϵ_it represents the random disturbance term. Among them, the parameter β_3 is of most interest in this study, and it is expected to be significantly negative, indicating that public health events such as the COVID-19 pandemic have significantly worsened the employment situation of enterprises.

Furthermore, to control for the interference of other time-varying factors and prevent bias in the results due to the direct correlation between disturbance terms and core explanatory variables, control variables are added to Model (1):

$$lnem_{i,t} = \beta_0 + \beta_1 \times Post_t + \beta_2 \times Treat_i + \beta_3 \times Post_t \times Treat_i + H \times CONTROL_{it} + \epsilon_{it} \quad (2)$$

In the formula, H is the coefficient matrix of control variables, control is the vector of control variables, including enterprise size (size), which is the natural logarithm of total assets, reflecting the different responses of enterprises of different sizes to the impact of the pandemic; debt ratio (lev), which is the total liabilities divided by total assets, used to evaluate the debt risk and employment capacity of enterprises; net fixed assets (fix), which is fixed assets divided by total assets, reflecting the relationship between labor and fixed assets; cash flow level (cash), which is the ratio of operating cash flow to total assets; return on assets (roa), which is the ratio of operating income to total assets, reflecting the operating condition of enterprises; wage level (wage), which is the ratio of accrued employee compensation to total assets, reflecting the cost of employment for enterprises.

Finally, the enterprise fixed effects μ_i and year fixed effects δ_t are added to the model:

$$lnem_{i,t} = \beta_0 + \beta_1 \times Post_t \times Treat_i + H \times CONTROL_{it} + \mu_i + \delta_t + \epsilon_{it}$$

Where the enterprise fixed effects absorb unobservable heterogeneity characteristics that only vary across enterprises and not over time, and the year fixed effects absorb macro-level shocks that only vary across years and not across individuals.

3 Empirical Results

3.1 Descriptive Statistics

From table 1, the observed values for the total number of employees in the above variables are 27616, with a mean of 7.605, a minimum value of 0.693, a maximum value of 13.14, and a standard deviation of 1.293, indicating significant differences in employment numbers among different companies. The observed values for the company size variable are 27618, with a mean of 22.234 and a standard deviation of 1.319, with a minimum value of 19.815 and a maximum value of 26.291. The observed values for the company's debt-to-equity ratio are 27618, with a mean of 0.412 and a standard deviation of 0.206, with a minimum value of 0.055 and a maximum value of 0.925. The observed values for the company's net fixed assets are 27614, with a mean of 0.193 and a standard deviation of 0.151, with a minimum value of 0.002 and a maximum value of 0.671. The observed values for the wage level variable are 27471, with a mean of 0.009 and a standard deviation of 0.009, with a minimum value of 0 and a maximum value of 0.051. The observed values for the company's cash flow level are 27618, with a mean of 0.013 and a standard deviation of 0.061, with a minimum value of -0.183 and a maximum value of 0.201. The observed values for the company's return on assets are 27612, with a mean of 0.367 and a standard deviation of 0.293, with a minimum value of 0.025 and a maximum value of 1.772.

Table 1. Descriptive statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
lnem	27616	7.605	1.293	.693	13.14
size	27618	22.234	1.319	19.815	26.291
lev	27618	.412	.206	.055	.925
fix	27614	.193	.151	.002	.671
wage	27471	.009	.009	0	.051
cash	27618	.013	.061	-.183	.201
Roa	27612	.367	.293	.025	1.772

Figure 1 presents the trend of employee-to-asset ratio for firms over time. The blue line represents the control group, assuming firms that did not experience shocks to their employment situation. It shows a clear seasonal variation, with higher employee-to-asset ratios during the year-end and year-beginning (first and fourth quarters), and lower ratios during the middle of the year (second and third quarters). This may be partly due to increased market demand and the need for firms to handle accumulated orders at year-end, leading to a higher employee-to-asset ratio as they try to maintain an adequate workforce under multiple pressures. The yellow line represents the experimental group, which recorded the employment situation of firms after experiencing shocks. After the shocks, the seasonal employment variation of firms was greatly impacted, transitioning from a stable cycle to varying degrees of decline. Over time, the degree of employment decline gradually increased, possibly due to firms adopting a pessimistic view of the market and expecting a prolonged recovery, leading to laying off employees or reducing their compensation. The decrease in wage levels due to the

large-scale unemployment caused by the bankruptcy of some large firms under pressure may also be one of the reasons.

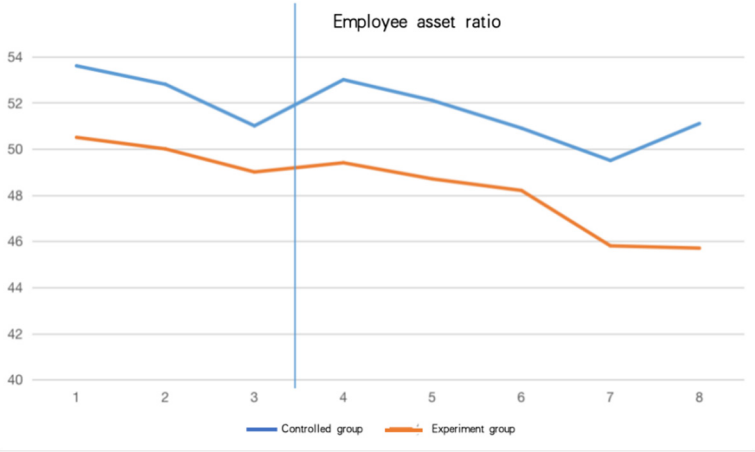

Fig. 1. Trend of Employee-to-Asset Ratio for Firms.

3.2 Baseline Results

Table 2 reports the impact of the COVID-19 pandemic shock on firm employment using three estimation models in the research design. In column (1), we do not control for any control variables and find that the estimated coefficient of treat and post is significantly negative at the 1% confidence level (-0.1143), indicating that the pandemic shock indeed suppressed firm employment. In column (2), we include firm-level control variables, and although the estimated coefficients of treat and post change to some extent, they are still significantly negative, indicating that our selection of control variables is reasonable. In column (3), we further control for firm fixed effects and year fixed effects, and the coefficients do not change significantly, remaining significantly negative, indicating the robustness of the model. In terms of economic effects, taking column (3) as an example, the pandemic shock led to a 6.6% decrease in employment level for the experimental group compared to the control group.

Table 2. The shock COVID-19 applies to firms

	(1)	(2)	(3)
	m1	m2	m3
VARIABLES	lnem	lnem	lnem
c.treat#c.post	-0.1143***	-0.0666***	-0.0660***
	(0.0312)	(0.0180)	(0.0179)
treat	0.0760***	-0.0082	
	(0.0225)	(0.0131)	
post	0.0534**	-0.0030	
	(0.0226)	(0.0132)	
size		0.7724***	0.7730***
		(0.0049)	(0.0040)
lev		-0.3428***	-0.3482***

		(0.0297)	(0.0258)
fix		1.1387***	1.1216***
		(0.0380)	(0.0307)
wage		40.8932***	40.7063***
		(0.6641)	(0.5232)
cash		-0.3854***	-0.2974***
		(0.0873)	(0.0774)
roa		0.5573***	0.6113***
		(0.0221)	(0.0163)
Constant	7.5688***	-10.1682***	-10.2013***
	(0.0163)	(0.1026)	(0.0856)
Fixed Effect	No	No	Yes
Observations	27,616	27,459	27,459
R-squared	0.001	0.670	0.672

Note: ***, **, and * represent significance at the 1%, 5%, and 10% confidence levels, respectively

3.3 Heterogeneous Firm Analysis

Table 3 reports the impact of the COVID-19 pandemic shock on employment in different types of firms. In columns (1) and (2), by comparing employment data of manufacturing and non-manufacturing firms, we find that the employment situation of non-manufacturing firms changed more significantly after the pandemic shock than that of manufacturing firms, and their asset-liability ratio and cash flow were negative, indicating that the public health event had a larger impact on non-manufacturing firms than on manufacturing firms.[4]

Columns (3) to (4) of Table 3 report the analysis of firms of different sizes. We find that small and medium-sized enterprises (SMEs) were more severely impacted in terms of actual employment than large enterprises, but their total fixed assets and asset-liability situation were relatively better than those of large enterprises, and their cash flow was less affected, indicating that SMEs tend to shrink their business scale, while large enterprises tend to maintain their production status by selling assets and other means in anticipation of market recovery. [1]

Table 3. Influences of the pandemic on different types of firms

	(1)	(2)	(3)	(4)
	Manufacture	Non-manufacture	Large firms	Mid/small firms
VARIABLES	lnem	lnem	lnem	lnem
c.treat#c.post	-0.0536***	-0.0621**	-0.0419	-0.0614***
	(0.0129)	(0.0268)	(0.0421)	(0.0134)
size	0.8225***	0.7884***	0.8624***	0.8112***
	(0.0030)	(0.0053)	(0.0130)	(0.0039)
lev	-0.0036	-0.4785***	-0.7203***	-0.2365***
	(0.0187)	(0.0349)	(0.0652)	(0.0184)
fix	0.9674***	0.9231***	0.8960***	1.2484***
	(0.0245)	(0.0369)	(0.0534)	(0.0235)
wage	31.6341***	46.9135***	48.0309***	37.8151***
	(0.3833)	(0.6134)	(1.3116)	(0.3491)
cash	0.1696***	-0.5823***	-0.4053*	-0.0739
	(0.0562)	(0.1111)	(0.2213)	(0.0556)
roa	0.3422***	0.6604***	0.8670***	0.4627***

	(0.0120)	(0.0191)	(0.0309)	(0.0114)
Constant	-11.1180***	-10.7704***	-12.3549***	-11.0349***
	(0.0629)	(0.1151)	(0.3129)	(0.0834)
Fixed effect	Yes	Yes	Yes	Yes
Observations	35,653	19,321	8,285	46,689
R-squared	0.761	0.628	0.461	0.579

Table 4 reports the impact of the COVID-19 pandemic on employment in different types of enterprises and regions. Columns (1) and (2) present the effects on private and state-owned enterprises. We found that in the sample of private enterprises, the estimated coefficient of the interaction term is significantly negative, while it is not significant in state-owned enterprises. This suggests that the pandemic has more significantly inhibited employment in private enterprises. This may be because state-owned enterprises, with their inherent state-owned attributes and greater social responsibility, are compelled to hire more employees to ensure employment or stabilize the market, even in the face of shocks, thus retaining more employees[9].

Columns (3) and (4) report the impact of the pandemic on enterprises in different regions. We found that in the densely populated and economically developed eastern regions, enterprises tend to lay off employees to cushion the impact. We speculate that this is because the dense population in eastern regions provides a large labor supply, leading enterprises to anticipate that they can quickly hire a large amount of labor at low cost and return to normal production levels after the shock ends. In contrast, enterprises in central and western regions do not have such expectations. The eastern region's tendency towards highly elastic demand in a perfectly competitive market may also be a contributing factor: enterprises must reduce costs to increase profits at existing price levels, as the market competition in the eastern region is fierce and consumers are more sensitive to price changes compared to the central and western regions, where any price increase would result in a significant decrease in total revenue. Therefore, enterprises in the eastern region must "cut tails to survive" during the shock.

Table 4. Impact of the COVID-19 pandemic on enterprise property rights and regional location.

	(1)	(2)	(3)	(4)
	Private enterprise	Public enterprise	Mid-west	East
VARIABLES	lnem	lnem	lnem	lnem
c.treat#c.post	-0.0714***	-0.0320	-0.0414*	-0.0658***
	(0.0148)	(0.0269)	(0.0245)	(0.0155)
size	0.7852***	0.8181***	0.7965***	0.7706***
	(0.0035)	(0.0052)	(0.0053)	(0.0033)
lev	-0.3112***	-0.3189***	-0.4881***	-0.2209***
	(0.0211)	(0.0350)	(0.0318)	(0.0222)
fix	1.4586***	0.9003***	0.8165***	1.3755***
	(0.0270)	(0.0366)	(0.0359)	(0.0273)
wage	40.3122***	39.6126***	32.8382***	43.2687***
	(0.4017)	(0.7044)	(0.6474)	(0.4198)
cash	0.0195	-0.7417***	0.0466	-0.2332***
	(0.0622)	(0.1186)	(0.1063)	(0.0655)
roa	0.5037***	0.5713***	0.6125***	0.4941***
	(0.0127)	(0.0205)	(0.0201)	(0.0128)
Constant	-10.4886***	-11.2803***	-10.5542***	-10.2464***
	(0.0754)	(0.1146)	(0.1144)	(0.0708)
Fixed effect	Yes	Yes	Yes	Yes
Observations	38,906	15,754	16,738	37,922
R-squared	0.657	0.673	0.652	0.688

3.4 Dynamic Effects

Table 5 reports the sustained impact of the COVID-19 pandemic on enterprises. We used the pre-pandemic period as the baseline, and the estimation results show that the coefficients for the 2nd and 3rd periods before the pandemic are not significant, but the coefficients for the 0th to 4th periods after the pandemic are significantly negative, with no clear downward trend in the magnitude of the coefficients. This suggests that the pandemic has caused sustained and short-term irreversible unemployment phenomena.

Table 5. Dynamic Impact of the COVID-19 Pandemic.

	(1)
	dd
VARIABLES	lnem
c.treat#c.b3	-0.0273
	(0.0259)
c.treat#c.b2	-0.0075
	(0.0257)
c.treat#c.p0	-0.0584**
	(0.0254)
c.treat#c.p1	-0.0826***
	(0.0254)
c.treat#c.p2	-0.0661***
	(0.0253)
c.treat#c.p3	-0.0647**
	(0.0251)
c.treat#c.p4	-0.0835***
	(0.0250)
size	0.7810***
	(0.0028)
lev	-0.3375***
	(0.0182)
fix	1.1438***
	(0.0214)
wage	39.7214***
	(0.3531)
cash	-0.1210**
	(0.0560)
roa	0.5344***
	(0.0108)
Constant	-10.3692***
	(0.0609)
Observations	54,660
R-squared	0.675

4 Conclusion

According to the research results, major public health events have a significant and short-term irreversible impact on employment in enterprises. This impact is mainly reflected in the decline in the number of employees and the continuous reduction of the employee-to-asset ratio. In addition, enterprises of different sizes tend to adopt different measures to cope with the impact. For example, small enterprises may choose to lay off

employees to reduce costs, while large enterprises may prefer to sell assets or take out loans to maintain production levels. This may be due to different perceptions of market share or future expectations. In terms of results, the main impact of major public health events has shifted from traditionally believed manufacturing enterprises to non-manufacturing enterprises. This may be directly related to the widespread adoption of automation and scale production, as well as the reduction in the number of employees, and indirectly related to the level of economic development and changes in consumer demand. In terms of the nature of enterprise ownership, state-owned enterprises often bear higher costs to guarantee basic employment due to their inherent social responsibility, while private enterprises tend to lay off employees to save costs. In terms of geographical location of enterprises, enterprises in economically developed regions are more inclined to lay off employees to save costs compared to those in central and western regions, possibly due to the abundant labor supply in densely populated areas.

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