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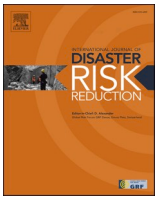
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Identifying effective measures to enhance the recovery of small and micro enterprises after multiple waves of COVID-19 – A case study from Dongguan, China

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ABSTRACT

The ability of a small and micro enterprise (SME) to recovery after a pandemic outbreak can directly affect national economic growth and sustainable development (Sustainable Development Goal 11). Thus, the current study quantitatively identifies, based on the spatial probit model, effective measures that enhance the performance and survival of SMEs after multiple waves of shocks induced by COVID-19. Additionally, this work explores the spatial correlation for post-pandemic recovery performance of businesses adopting a novel approach. Two field investigations were conducted in Dongguan City, in China, where questionnaires were released to 592 SMEs over a two-year period. The results obtained showed that the overall recovery performance of SMEs after the pandemic showed a positive spatial correlation, while this correlation varied at different local regions. More in detail, self-media marketing, borrowing money from family or friends, requesting bank loans and tax relief have been identified to be the key measures to effectively support the recovery and the increase chances for small businesses to remain operative after the pandemic. However, the success of these measures varies across businesses with different characteristics (owner's age and industry experience, primary market and business size, pre-pandemic financial condition). It is then suggested based on the results obtained that policy managers should formulate differentiated policies in terms of assistance measures for businesses targeting dissimilar characteristics as well as the needs of different regions, because those may have been impacted differently by the pandemic.

1. Introduction

Worldwide business operations can daily be exposed to potential disruptions that range from various types of uncertain emergencies, for example disasters, production accidents and public health events [1–3]. The novel coronavirus pneumonia outbreak in late 2019 (COVID-19) was the fastest spreading and most widespread public health emergency since the founding of New China (1949) [4], [5], [6]. In late 2022, the full liberalization of the pandemic-lockdowns sanctioned China's basic environment from the phase of

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normalized pandemic prevention to the post pandemic era. However, it is fundamental to stress that the prolonged shock caused by the pandemic between 2019 and 2022 has had a serious impact on the survival and development of small enterprises, leading to low operating profits, high vulnerability, and short life cycles, aspects which nowadays seriously threaten economic and social stability and sustainable development [7–12].

Small businesses for retail industry in China have between $147,800- $738,800 of revenue, and between 10 and 50 employees, while micro businesses have less than $147,800 revenue and less than 10 employees. On the other hand, medium and large businesses for retail industry in China have between $738,000- $29,520,000 of revenue, and between 50 and 300 employees for the first category, and more than $29,520,000 of revenue, and more than 300 employees for the latter. Thus, small and micro businesses (SMEs) may be more vulnerable to crisis and have a harder time recovering from it than medium/large businesses because the formers usually have a high risk of revenue loss [13], poor financial condition [14], weak disaster planning [1], limited technological skills [15], and limited support resources [16]. These characteristics are crucial and can then lead to significant differences in the crisis response or in the recovery paths between SMEs and medium/large businesses. For example, the weak disaster planning of SMEs may easily lead them to be overwhelmed after an outbreak and take highly randomized coping measures without a specific plan [17]. Moreover, the high vulnerability may lead to a greater amount of workload faced by SMEs to cope with a crisis [13] and no relevant funding to cover those tasks. Finally, SMEs have limited access to external support resources, and they may tend to get help from friends, relatives, or family to cope with a crisis [18], thus generating other debts to close members. According to statistics, SMEs accounts for more than 80% of the total number of Chinese enterprises and contributes more than 60% to GDP [19]. Therefore, the resilience and ability to recover of SMEs after external shocks such as COVID-19 global pandemic are particularly predominant and imperative.

The performance of SMEs after the pandemic shock has been the goal of several studies. More in detail, some have explored the differences in retail sales before and after the pandemic [20–23], the differences in income of small leisure and hospitality sectors [10,24,25] and the differences in consumer mindset [10,26–29], as well as spatial differences in firm vulnerability during the pandemic [30] from a macro perspective. On the other hand, additional studies have been conducted from a micro point of view to gain an in-depth understanding of each enterprise's operation through literature review, questionnaires, interviews, etc. [31–33]. Most of them focus on two aspects: the first one is the impact of the pandemic on the enterprise [13,16,34–36], while the second one regards the measures taken by each enterprise to cope with the pandemic [37–39]. However, most of the abovementioned studies are based on questionnaire or interview data qualitatively describing the enterprises' performance in the context of the pandemic and lack quantitative tests of the effectiveness of firms' responses to the pandemic on their recovery outcomes.

Finally, a few studies have explored the factors influencing the recovery of firms after the shocks caused by the pandemic through quantitative methods [40–42]; Most of them focused on the performance of firms after a particular epidemic shock, however, lack insights into their recovery following multiple waves of the pandemic and the consequent lockdowns targeting the long-term perspective. Furthermore, the abovementioned studies also ignore the influence of spatial correlation factors for example the geographical location of an enterprise, which has been demonstrated to affect recovery of a business after external shocks [43–45]. Thus, adding the geospatial factors into the modeling would be hugely beneficial in enriching the results obtained to date.

To address this gap, the current study takes Dongguan City, in China, as an example, exploring the spatial correlation of post-pandemic recovery performance of SMEs and constructing a spatial probit model to test the effectiveness of enterprise response measures on their recovery outcomes following multiple pandemic waves. Data was obtained through a 2-year questionnaire interviews and field investigations on 592 owners of SMEs in 23 districts of Dongguan City. Theoretically, the current study provides a research of businesses recovery after a prolonged (multi-wave) pandemic shock, which helps to enrich existing theories of enterprise risk-management that have been developed so far but focus on short-period shocks. Practically, the current study is dedicated to identifying effective measures to promote enterprise recovery after long-term pandemic shocks, to accumulate experience related to enterprise crisis management in the context of any pandemic. Moreover, this study aims to contribute to three essential practical goals, which refer to i) improve the resilience and recovery capacity of small and micro enterprises after potential risk shocks in the future; ii) enhance the ability of enterprise operators and policy managers to cope with external shocks, and iii) promote economic and social stability and sustainable development.

2. Business measures to cope with the COVID-19 pandemic

Existing studies have summarized many measures that may affect the recovery of businesses after the pandemic, which can be roughly divided into two categories: the internal adjustment measures and the external resources obtained by businesses to cope with the impacts of the pandemic. The first category mainly refers to the behavior of businesses to adjust their internal personnel, products, and technologies in response to the pandemic, involving actions such as layoffs, technological reforms, online transformation, opening branches, and self-media marketing. Abu Hasan et al. (2022) and Siuta-Tokarska [46] conducted extensive literature and implemented questionnaires and were able to summarize the main measures for SMEs to cope with the pandemic, including reduction of employees, online transformation or digitization, technological innovation and training, and opening branches in areas less affected by the pandemic [33,46]. Digital technology and online transformation were the most widely used strategies by SMEs during the pandemic. Indeed, Drydakis [47] and Gao et al. [42] found that Artificial Intelligence (AI) and digital marketing strategies can improve the productivity and financial performance of SMEs, reduce business risks and improve the sustained performance of the business during the pandemic [42,47]. There is evidence that planning to combat a crisis has a significant impact on business resilience [1,48]. However, Katare et al. [40] found that not all transformation measures can help improve the survival outcomes of a business. For example, adopting an online transformation may not work initially, nevertheless increasing a business's influence on social media could reduce revenue loss and recovery time [40].

The external resources obtained by any enterprise in response to the pandemic can be categorized into three main types: i) bonding resources, ii) bridging resources, and iii) indirect resources [49]. The first ones refer to resources that are strongly related to the enterprise and aid its initial recovery, for example the help provided by family or friends. The second category incorporate resources that are weakly related to the businesses and promote them to obtain more help, for example supplier assistance. The last group is associated with resources that do not have a direct relationship with the enterprise, but can provide convenience for the businesses, such as governmental enable policies [50]. Many studies have pointed out that SMEs usually have worse recovery outcomes from external crisis than large firms because the former have less access to external assistance resources than the latter [15,18]. Fauzi et al. [37] and Katare et al. [40] believe that government assistance measures (such as subsidies, tax relief, rent relief, etc.) are conducive to increasing business resilience and helping business survive the pandemic [37,40]. Nevertheless, the effect of the governments' assistance on improving businesses' resilience may vary across industries and businesses of different sizes [51]. SMEs with limited access to government or institutional support resources may be inclined to seek help from relatives or family to cope with the crisis [18].

The abovementioned research found in literature provide an important reference for the current study to investigate the key measures that affect the recovery outcomes of businesses following a pandemic. However, most of the previous studies found in literature summarize the measures adopted by businesses qualitatively through literature reviews or questionnaire surveys, and therefore lack further quantitative testing of the effectiveness of these measures in promoting the outcomes of the recovery for each business after the COVID-19 crisis. Moreover, spatial factors are considered to have a significant impact on the recovery outcomes of businesses after an external crisis, and most of the existing studies have neglected them in their modeling [44]. In addition, most existing studies focus on the business performance after the pandemic in early 2020 and lack attention to the scenarios of recovery of businesses after the impact of multiple waves of pandemics. For example, China's pandemic control lasted for three years (from the end of 2019 to the end of 2022), which provided a rare opportunity to study long-term external shocks compared to most disasters or accidents that occur in a short period (such as typhoons, floods, earthquakes, fires, explosions, etc.). Comprehensively, considering spatial factors in modeling and identifying quantitatively effective measures affecting the recovery outcomes of businesses after long-term COVID-19 crisis is of great significance for guiding business owners and managers to effectively cope with long-term crisis and thus promote economic and social stability.

In addition to all the measures described, there are also other factors that may affect the recovery of businesses after the pandemic, for example, owner characteristics and businesses characteristics [52–56]. Pongtanalert and Assarut [49] argued that entrepreneurial mentality affects businesses' adaptability after a pandemic shock [49]. Helgeson et al. [57] proclaimed that female-owned firms are more severely affected by pandemics [57] and that male-owned businesses have better survival outcomes after pandemic shocks [58]. Businesses owned by highly educated or older experienced owners were expected to achieve better recovery performance after an external shock than their counterparts [43,58,59].

Additionally, business characteristics may also influence their recovery outcomes after the pandemic. Businesses in different industries, sizes and financial conditions encountered different problems during the pandemic, which can all affect the recovery of businesses affected by pandemic shocks [58]. Most studies found that large businesses are able to get access to more resources to help them recover, and thus, they recover faster than the SMEs [13,16]. Leased businesses still must pay rent despite low revenues during the pandemic period and may face worse financial conditions compared to owned ones [60]. Good financial conditions before the pandemic shock can help firms to keep their capital chain intact during the COVID-19 crisis, thus promoting the continued operation of the businesses [40].

It is worth noting that the concept of recovery is not uniform across the world because some previous works define recovery as the return of a system to a normal state or to its pre-crisis state [61–63], while other studies believe that recovery is a subjective concept and that whether a system recovers or not depends on people's subjective judgment [64]. Furthermore, a relatively widely accepted concept states that recovery is the ability of a system to recover and rebuild quickly from a shock [65–67] and a number of studies have defined the recovery ability of a system as its resilience, specifically adaptation resilience [68–70]. Distinguished from internal resilience, which emphasizes the ability of a system to cope with potential disasters, adaptation resilience accentuates the ability of a system to respond and recover from a crisis [71,72]. Therefore, there is a cross-correlation or overlap between the concepts of recovery and resilience, and both can reflect a system's ability to cope with environmental change [56,73]. However, both the concepts of recovery and resilience have gradually shifted from emphasizing the return of the system to pre-crisis levels to the adaptation of the system to the new post-crisis environment [54,74,75]. Clarifying the concept of recovery is fundamental to measure the recovery rate of businesses. Existing research on this topic mainly measures business recovery performance in terms of whether a business reopens after a crisis, or measures the speed of recovery in terms of the length of time it takes for a business to reopen after a crisis [40,44,59]. The field of business resilience mainly use financial indicators, physical indicators and spatial indicators, or a combination of multiple aspects, with financial indicators and supply chain indicators being the relatively most important indicators of post-pandemic business resilience concerns [76–79]. Based on this, the current study combines previous research and considers the accessibility of various indicators and measures the recovery of businesses after the pandemic shock in terms of the survival status (open or closed) and operational status (changes in the level of average profitability).

The current study aims to contribute to this field by identifying effective measures that can affect the recovery outcomes of businesses after multiple waves of pandemic crisis, which is lacking within existing studies. The main goal focuses on improving the accuracy of numerical modelling predictions by incorporating factors in Table 1. Some indicators had been previously mentioned, but only qualitatively, however the effectiveness of these indicators had not been tested quantitatively. Furthermore, others were studied but not in the context of global pandemic. Accordingly, the current study aims to address the following two research questions.

Table 1
Summary of factors considered for the modeling of businesses' survival dealing with shocks induced by a pandemic.

Categories		Indexes	References
Measures to cope with the pandemic	Internal adjustment measures	Layoffs	[33,46]
		Technology reform and innovation	[42,47]
		Online transformation	[40]
		Opening branches	[31,46]
		Purchase of anti-pandemic materials	[1,48]
		Self-media marketing	[40]
	External resources	Borrow money from family or friends	[18]
		Bank loans	[15,18]
		Tax relief	[37,50]
		Rent relief	[37,40]
		Advance goods from suppliers	[49]
Additional factors	Owner characteristics	Age	[58,59]
		Gender	[57,58]
		Education	[43,59]
		Industry experience	[43,58]
		Owner' confidence in the Business climate	[49]
	Business characteristics	Type of business	[58]
		Owned or leased facility	[60]
		Primary market	[58]
		Business size	[13,16]
		Pre-pandemic financial condition	[40]
	Spatial factor	The distance between businesses	[44]

(1) What are the spatial correlations of recovery performance of SMEs after multiple waves of pandemics?
(2) What response measures are effective in facilitating SMEs recovery after multiple pandemic waves considering spatial correlations?

3. Methods

3.1. COVID-19 pandemic and the study area

Dongguan is in the South of China, more specifically in the south-central part of the Guangdong Province, and it is adjacent to two first-tier cities, Shenzhen, and Guangzhou, to the north and south respectively, as shown in Fig. 1. By the end of 2022, Dongguan had 10.437 million permanent residents, of which 9.628 million were urbanized, with an urbanization rate of 92.25%. Dongguan has a total area of 2542.67 square kilometers, with 4 central urban districts and 28 towns under its jurisdiction. Unfortunately, the high urbanization rate, the dense urban population, and the close connection with other cities were all prerequisites that facilitated a rapid spread of COVID-19 pandemic [71,80–82].

As it also happened for many other cities in China, Dongguan has been fighting the pandemic for three years (end of 2019 - end of 2022). The initial outbreak at the end of 2019 was mainly concentrated in Wuhan, China, and at this time of the year there is the Spring Festival which unfortunately enabled a more intense spread of the pandemic through China due to people returning from this event to their homes [83–85]. Between the end of 2019 and June 2021, Dongguan was mainly dealing with confirmed COVID-19 cases coming from Wuhan. Timely screening and isolation of imported cases from Wuhan resulted in little transmission between these infected persons and Dongguan natives, and as a result, production and life in Dongguan was relatively normal. The government did not take wide-scale lockdown measures, and the impact of the pandemic on businesses was mild during this period. However, in other regions such as Wuhan itself, consequences of the pandemic were severe. From June 2021 to December 2022, the pandemic began to spread wantonly in local Dongguan, and then Dongguan's government had to take a certain range of lockdown measures, resulting in a large number of businesses being seriously affected by the pandemic. The city experienced a total of five waves of pandemics, with the specific development timeline shown in Fig. 2. It should be noted that, according to the data published by the Dongguan Municipal Health Bureau, the current study takes into consideration the fact that if both confirmed and new cases recorded are 0 for more than 14 days, this corresponds to the end of a certain wave of the pandemic [86]. Among the five waves of the pandemic, two of them (2022.6.1–2022.6.10 and 2022.7.7–2022.7.16) had only 1 new confirmed case, indicating that the pandemic was relatively mild,

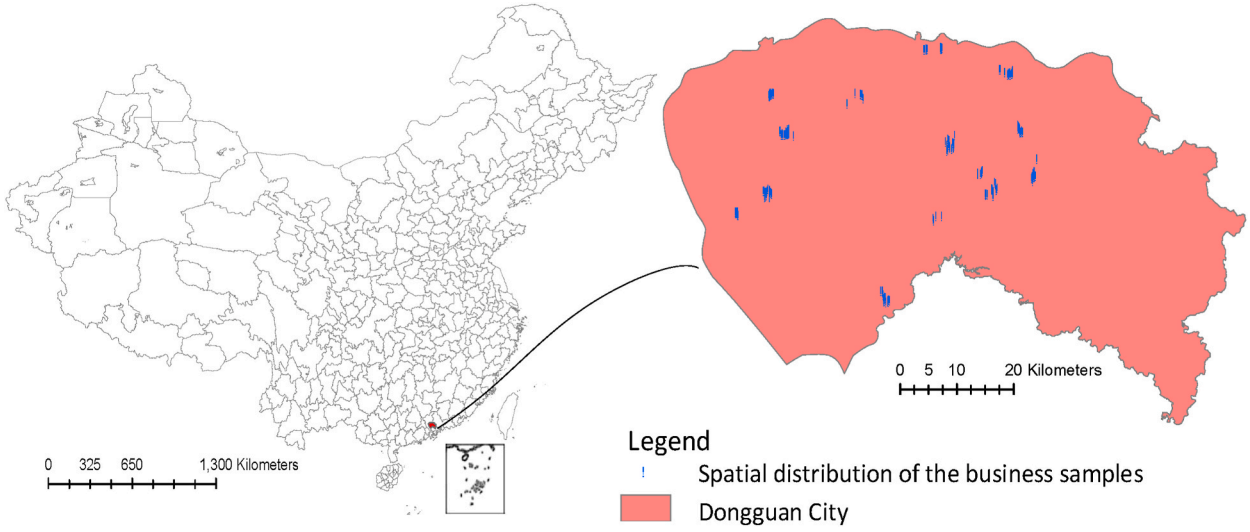


Fig. 1. Study area and geographical distribution of the samples.

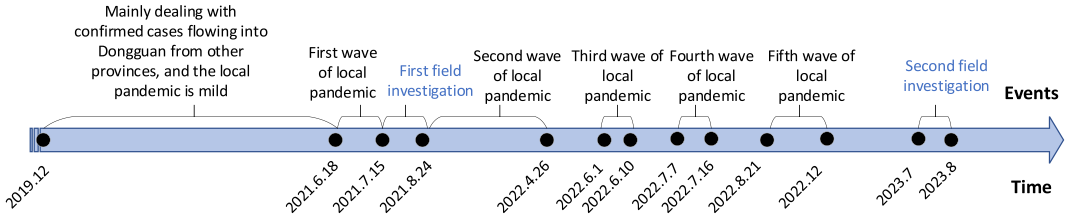


Fig. 2. Timeline of the field investigation conducted and of the development of the pandemic in Dongguan.

while the remaining three-time phases (2021.6.18–2021.7.15, 2021.8.24–2022.4.26, and 2022.8.21–2022.12) faced more severe effect and infected people.

3.2. Data collection and methods applied

3.2.1. Sampling procedure

The current study is devoted to identifying additional effective measures that may influence the rate of recovery and the performance of businesses affected by multiple waves of pandemic. The datasets were obtained from two field investigations and questionnaire surveys of 592 SMEs in 4 central urban districts (Dongcheng Street，Nancheng Street，Guancheng Street, Wangjiang Street) and 15 towns in Dongguan, affected by relatively severe infected people. The first field investigation and questionnaire survey were conducted in July 2021 and the second in July 2023, two years later. The former was used to understand the response measures, the owner's characteristics, and the businesses' characteristics during the pandemic period; the latter, six months after the full liberalization from the pandemic's lockdown, was used to understand the response measures and the performance of businesses to recover after the pandemic.

Other 13 towns in Dongguan, including Qishi, Qiaotou, Dongkeng, Zhangmutou, Xiegang, Tangxia, Qingxi, Fenggang, Mayong, Zhongtang, Gaobu, Shijie and Hongmei, were considered to have very few confirmed cases during the outbreak period, and

Table 2
Distribution of valid business samples collected.

Name of town	Number of valid samples	Name of town	Number of valid samples
Chashan Town	20	Humen Town	41
Changping Town	40	Liaobu Town	26
Dalang Town	46	Nancheng Street	22
Dalingshan Town	31	Shatian Twon	38
Daojiao Town	29	Shilong Town	39
Dongcheng Street	20	Shipai Town	41
Guancheng Street	20	Wangniudun Town	29
Hengli Town	40	Wangjiang Street	20
Houjie Town	31	Chang'an Town	39
Huangjiang Town	20	Total	592

experienced mild outbreak shocks, thus, these towns were excluded from the study. For the remaining 15 towns and 4 central urban districts considered, the relatively busiest and most densely populated areas of the city center with the highest concentration of SMEs were selected. Basic information such as the name, location, and business type of the SMEs were observed and recorded, and business owners were asked to do a questionnaire survey to get a comprehensive understanding of the response measures implemented and the survival status of the SMEs after the pandemic. After excluding samples owned by those who are unwilling to participate in the survey or those whose questionnaires were incomplete, the number of valid business samples for each town or central urban district is shown in Table 2 and the spatial distribution of these business samples is shown in Fig. 2.

3.2.2. Node variables

The current study identifies effective measures affecting the recovery performance of SMEs after multiple waves of pandemic crisis based on a spatial probit model. The selected dependent variable is the recovery performance of the businesses, the independent variable is the response measures of the businesses to cope with the pandemic, and the control variables are the characteristics of the owner characteristics and the characteristics of the businesses. The recovery performance of SMEs is grouped into four categories (see Table 3): SMEs can perform better, or the same way, or worse after the pandemic (2023.1–2023.7) than they did before the pandemic (before 2020.1), denoted by 3, 2, and 1, respectively. Poor recovery performance that leads to the closure of a business is denoted by 0. A business was defined as closed if it had been not opened for more than three months at the time of the field investigation, and this judgment was confirmed by inquiring surrounding businesses or locals living in the area.

The response measures for SMEs include 6 internal adjustment measures and 5 external assistance measures, calculated dichotomously: i) whether the business has taken measures of layoffs (or technology reform and innovation, or online transformation, or opening branches, or purchase of anti-epidemic materials, or self-media marketing); ii) whether the business borrowed money from family or friends (or received bank loans, or received tax relief, or received rent relief, or advanced goods from suppliers). These measures are taken specifically in response to the pandemic and do not count if they were used before the COVID-19 pandemic.

The control variables include 5 variables describing the owner characteristics and 5 variables describing the businesses characteristics. Gender, owned or leased facility are as well both measured dichotomously. Business types are divided into four categories: manufacturing, wholesale/retail, service, others. Among them, manufacturing mainly includes food processing, textile manufacturing, furniture manufacturing; wholesale/retail mainly includes daily necessities, clothing, building materials, books and stationery, digital products, automobile accessories; service mainly includes restaurants, beauty salons, hotels, agencies, bars; and others mainly includes software development, advertisement design. Considering that dividing business types into more than a dozen categories may lead to bias in the results of the regression model, the business types were therefore grouped into these four categories. The other variables, owner's age, education, industry experience, confidence in the business climate, primary market, business size, pre-pandemic financial condition, are all measured on ordinal scale. Of these, "confidence in the business climate" is measured by asking the owner "How do

Table 3
Index and coding scheme selected for the variables involved in this study.

Indexes	Coding scheme
Business recovery performance	0 = closed, 1 = performance is worse after the pandemic than before the pandemic, 2 = performance after the pandemic was like that before the pandemic, 3 = performance is better after the pandemic than before the pandemic
Business response measures	Whether the business has taken the following COVID-19 response measures?
Layoffs	1 = yes, 0 = no
Technology reform and innovation	1 = yes, 0 = no
Online transformation	1 = yes, 0 = no
Opening branches	1 = yes, 0 = no
Purchase of anti-pandemic materials	1 = yes, 0 = no
Self-media marketing	1 = yes, 0 = no
Borrow money from family or friends	1 = yes, 0 = no
Bank loans	1 = yes, 0 = no
Tax relief	1 = yes, 0 = no
Rent relief	1 = yes, 0 = no
Advance goods from suppliers	1 = yes, 0 = no
Control variables	Owner characteristics and business characteristics
Age	1 = 20 or below, 2 = 21–35, 3 = 36–50, 4 = 51 and above
Gender	1 = male, 2 = female
Education	1 = primary school or below, 2 = junior middle school, 3 = high school/junior college, 4 = university degree or above
Industry experience	1 = less than half a year' experience, 2 = 0.5–2years' experience, 3 = 2–3.5years' experience, 4 = 3.5–5years' experience, 5 = more than 5 years' experience
Owner' confidence in the business climate	1 = extremely confident, 2 = relatively confident, 3 = moderate, 4 = little confident, 5 = no confident
Type of business	1 = manufacturing, 2 = wholesale/retail, 3 = service, 4 = others
Owned or leased facility	1 = owned facility, 2 = leased facility
Primary market	1 = national, 2 = provincial, 3 = municipal, 4 = town, 5 = local
Business size	1 = 1 full-time employees, 2 = 2–4 full-time employees, 3 = 4–10 full-time employees, 4 = 10–50 full-time employees
Pre-pandemic financial condition	1 = extremely good, 2 = relatively good, 3 = moderate, 4 = relatively bad, 5 = extremely bad

you think the business climate will be in the future compared to the present?" The answers "Much better; A little better; About the same; A little worse; Much worse" indicate "Extremely confident; Relatively confident; Moderate; Little confident; No confident", respectively (see Appendix 1).

3.2.3. Statistical method

(1) Spatial probit model

The ordered probit model is applicable to ordered categorical variables, i.e., the dependent variable has multiple possible values, and these values have a certain order relationship. This model was adopted because the dependent variable of the current study, post-pandemic recovery performance, is an ordered categorical variable, and most of the previous studies have used ordered probit model in solving the related problems [44,87]. It indicates that the use of ordered probit model to solve the question of the current study has a certain assumption and its expression is as follows:

$$Y = \beta X + \varepsilon \tag{1}$$

Where , β is the coefficient matrix, X is the dependent variable matrix, ε is the error term.

If there is a spatial correlation in the dependent variable, it is necessary to introduce a spatial matrix W, forming a spatial probit model based on the ordered probit model. The expression is as follows:

$$Y = \beta X + \rho WY + \varepsilon \tag{4}$$

$$W = \begin{bmatrix} 0 & \frac{1}{d_{12}} & \cdots & \frac{1}{d_{1n}} \\ \frac{1}{d_{21}} & 0 & \cdots & \frac{1}{d_{2n}} \\ \cdots & \cdots & \cdots & \cdots \\ \frac{1}{d_{n1}} & \frac{1}{d_{n2}} & \cdots & 0 \end{bmatrix} \tag{5}$$

Where, ρ is a spatial autocorrelation parameter, and W is a spatial weight matrix of n × n, which is used to represent the spatial position relationship between n samples. Based on the law that the spatial weight correlation decreases with the increase of distance [88], the inverse of the distance between sample points is used to represent the strength of its spatial correlation, and d_{ij} represents the distance between sample point i and j. It is worth noting that in spatial measurement, distance means that it can denote geographic proximity or Euclidean distance, but also the proximity of a cooperative relationship in the economic sense, or even the closeness of an interpersonal relationship in the sociological sense [89]. Considering that the current study mainly focuses on the recovery of SMEs in different geographic locations after the pandemic, thus, distance refers to physical distance.

(2) Global Moran's I

The Moran's I, a widely used index to describe spatial correlation, was used in the current study to explore the spatial correlation of variables. The Moran's I index includes global Moran's I, which indicates the spatial correlation of a variable for the whole region; and local Moran's I, which indicates the spatial correlation of a variable for different local areas in this region [44]. The global Moran's I is calculated by the following formula:

$$I = \frac{n}{S_0} \times \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_i - \bar{y})(y_j - \bar{y})}{\sum_{i=1}^{n}(y_i - \bar{y})^2} \tag{2}$$

$$S_0 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij} \tag{3}$$

Where, I is the value of Moran's I, n is the number of samples, y_i and y_j denote the attribute values of the i^{th} and j^{th} samples, respectively, $\bar{y}$ is the mean of the attribute values of all the samples, and w_{ij} is the value of the spatial weights. The value of global Moran's I is in the range of −1 to 1. If it exceeds 0, it denotes a positive autocorrelation, while if its value is less than 0 it indicates a negative autocorrelation, and if it is close to 0 it indicates no spatial autocorrelation.

(3) Local Moran's I and LISA cluster map

In order to further understand the local spatial correlation of variables and the significance of their correlations, the local Moran's I was calculated and the corresponding LISA cluster map was generated. The map usually includes the following four spatial correlation forms: (1) HH, the region characterized by high values and high values clustered, indicating that the attribute values of a variable are high in this region and also high in its surrounding areas, revealing a significant positive spatial autocorrelation for this variable in this

region; (2) HL, the region characterized by high values and low values clustered, indicating that the attribute values of a variable are high in this region but low in its surrounding areas, revealing a significant negative spatial autocorrelation for this variable in this region; (3) LH, the region characterized by low values and high values clustered, indicates that the attribute values of a variable are low in this region but high in its surrounding areas, revealing a significant negative spatial autocorrelation for this variable in this region; (4) LL, the region characterized by low values and low values clustered, indicating that the attribute values of a variable are low in this region and also low in its surrounding areas, revealing a significant positive spatial autocorrelation for this variable in this region.

4. Results

4.1. Descriptive analysis

The distribution of the performance of SMEs that recovered after multiple waves of COVID-19 pandemic is shown in Fig. 3. Of the 592 SMEs, 115, or 19%, closed because of the pandemic shock; 196, or approximately one-third, reported worse performance after the pandemic than that before the pandemic; 166, or 28%, reported approximate performance after the pandemic than that before the pandemic; only 115, or 20%, reported better performance after the pandemic than that before the pandemic. Table 4 and Appendix 2

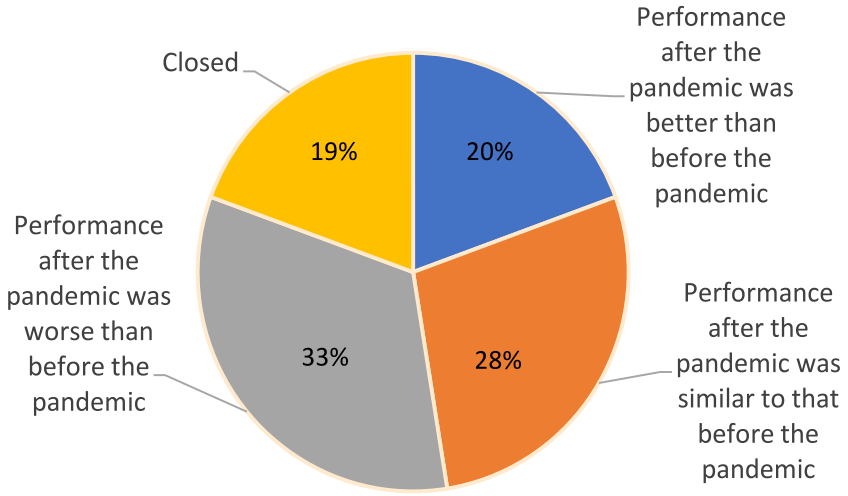


Fig. 3. Distribution of the recovery performance of SMEs after the pandemic.

Table 4
Statistics for variables adopted for this study and run with the probit model.

Indexes	Mean	St. dev.	Max	Min
Dependent variable				
Business recovery performance	1.475	1.013	3	0
Independent variables				
Layoffs	0.091	0.288	1	0
Technology reform and innovation	0.054	0.226	1	0
Online transformation	0.137	0.344	1	0
Opening branches	0.024	0.152	1	0
Purchase of anti-pandemic materials	0.956	0.205	1	0
Self-media marketing	0.083	0.276	1	0
Borrow money from family or friends	0.144	0.351	1	0
Bank loans	0.118	0.323	1	0
Tax relief	0.140	0.347	1	0
Rent relief	0.181	0.385	1	0
Advance goods from suppliers	0.052	0.223	1	0
Control variables				
Age	2.726	0.639	4	1
Gender	1.517	0.499	2	1
Education	2.530	0.790	4	1
Industry experience	4.289	0.915	5	2
Owner' confidence in the business climate	2.581	0.645	5	1
Type of business	2.493	0.615	4	1
Owned or leased facility	1.899	0.318	4	1
Primary market	3.895	1.087	5	1
Business size	2.056	1.069	4	1
Pre-pandemic financial condition	2.544	0.713	5	1

show the descriptive results of the independent variables, dependent variables, and control variables in the spatial probit model. The mean of recovery performance for SMEs after multiple waves of pandemic crisis is 1.475, which is between "*performance is worse after the pandemic than before the pandemic*" and "*performance after the pandemic was similar to that before the pandemic*". It indicates that the performances of most SMEs have not recovered to the pre-pandemic level in the six months after the full liberalization from the lockdowns induced by the pandemic.

Regarding the response measures taken by the SMEs to cope with the pandemic, the purchase of anti-pandemic materials (for example, masks, disinfectants, hand sanitizers, etc.) is the most widely used measure, with a mean value of 0.956, indicating that, 95.6% of SMEs have adopted this measure. The next most widely used measure was the online transformation, with a mean value of 0.137. It was expected that many SMEs would adopt this technique during the pandemic, but since some SMEs already had an online service model in place before the pandemic, only 13.7% of them implemented it after the pandemic. Few SMEs adopted measures such as layoffs, technology reform and innovation, and opening branches, accounting for only 9.1%, 5.4% and 2.4% respectively. Several SMEs received help from the following external sources: 14.4% borrowed money from family or friends, 11.8% asked for bank loans, 14% demanded tax relief and 18.1% sought rent relief, respectively. The relatively smallest number of SMEs, 5.2%, advanced goods from suppliers.

In terms of the control variables, the mean value of gender is 1.517, indicating that the proportion of male and female owners participating in the survey is relatively similar. The mean value of industry experience is 4.289, indicating that most of the owners have more than three and a half years' experience. The mean value of owners' confidence in the business climate is 2.581, which is between "relatively confident" and "moderate confident," indicating that most business owners' confidence between partial to optimistic. The mean values of the primary market and the business size are 3.895 and 2.056, respectively, indicating that most businesses serve the township market, and have 2–4 employees. The mean value of pre-pandemic financial conditions is 2.544, between "relatively good" and "moderate", indicating that the financial condition of most SMEs before the pandemic was partial to optimistic.

4.2. Results of Moran's I index

The global Moran's I index for the dependent variable 'post-pandemic recovery performance' was calculated and the results are displayed in Fig. 4. It is shown that the value of Moran's I index is 0.049, which is significant at the 1% level. It indicates that there is spatial autocorrelation between the post-pandemic recovery performance of SMEs. That is, overall, the correlation between post-pandemic recovery performance of SMEs became increase significant as their spatial locations clustered. Thus, the use of the spatial probit model may improve the accuracy of the results.

The same method was used to calculate the global Moran's I and its statistical test parameters for various pandemic response measures taken by SMEs (see Table 5). It is shown that the global Moran's I of all variables exceed 0, and the p-value are all below 0.05, indicating that these variables all have a positive spatial autocorrelation and significant at the 95% level. Taking layoffs as an example, this result indicates that there may be clustering in spatial distribution of SMEs that take layoffs measures. The majority of the global Moran's I for these variables range from 0 to 0.3 (close to 0), indicating a relatively weak spatial aggregation of response measures taken by many SMEs in the study area.

The LISA cluster map of the post-pandemic recovery performance of SMEs is presented together with three response variables with the relatively highest global Moran's I (tax relief, borrow money from family or friends, online transformation) in order to show their

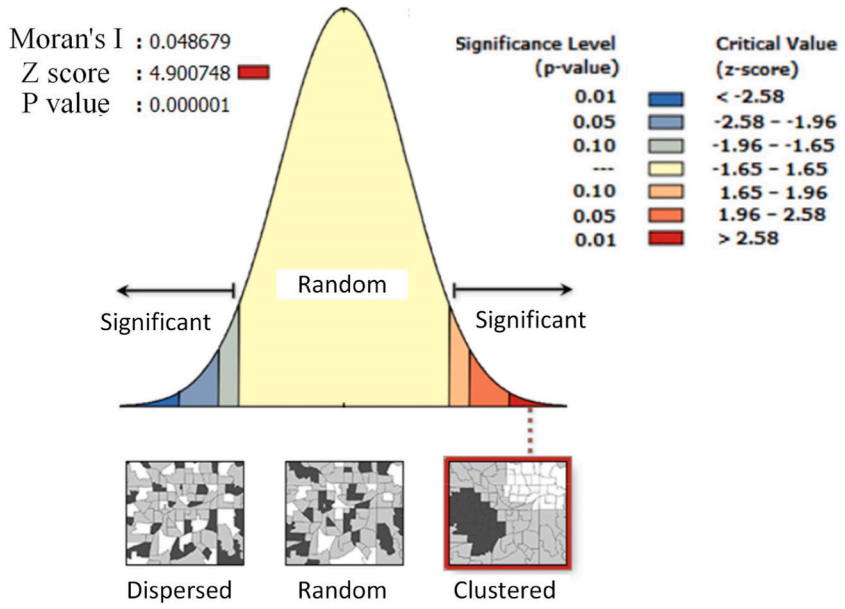


Fig. 4. Results of global Moran's I index for post-pandemic business recovery performance.

Table 5
Results of global Moran's I index for pandemic response measures.

Index	Global Moran's I	Z score	P value
Layoffs	0.142	14.228	0.001
Technology reform and innovation	0.144	14.585	0.001
Online transformation	0.169	16.982	0.001
Opening branches	0.042	4.605	0.002
Purchase of anti-pandemic materials	0.156	14.884	0.001
Self-media marketing	0.054	5.708	0.003
Borrow money from family or friends	0.203	20.410	0.001
Bank loans	0.164	16.649	0.001
Tax relief	0.286	28.251	0.001
Rent relief	0.147	14.862	0.001
Advance goods from suppliers	0.148	15.894	0.001

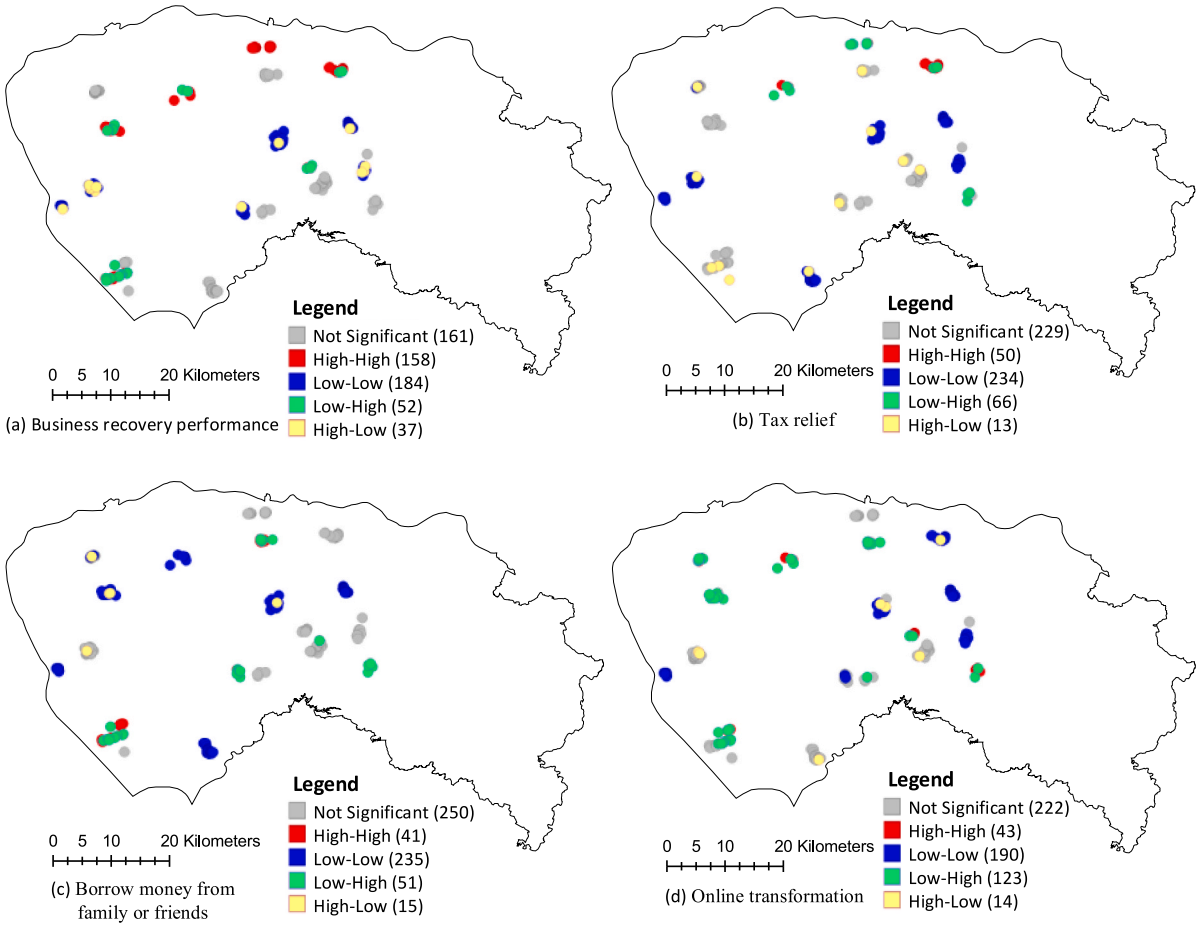


Fig. 5. Results of LISA cluster map for several variables.

local spatial correlations (see Fig. 5). It is demonstrated that the spatial correlation of SMEs recovery performance after the pandemic presents certain regional differences. The areas with extremely good recovery performance, charactered by high- and high-value clustered, are mainly located in the northern part of the study area. The areas with extremely poor recovery performance (charactered by low- and low-value clustered) are mainly located in the middle part of the study area, which is close to the areas with good recovery performance (charactered by high- and low-value clustered). The areas with poor recovery performance, charactered by low- and high-value clustered, are scattered across various towns and even streets. It can be inferred that the spatial correlations of post-pandemic recovery performance of SMEs not only exhibit differences at the macro level of the whole city, but may also vary among different towns or even streets at the micro level.

Table 6
Results of the spatial probit model.

Indexes	(1)		(2)	
	β	Std. Error	β	Std. Error
Layoffs	0.216	0.361	0.447	0.637
Technology reform and innovation	0.429	0.632	0.316	0.863
Online transformation	−0.107	0.168	0.204	0.469
Opening branches	13.797	4.776	14.981	3.389
Purchase of anti-pandemic materials	0.0191	0.238	0.251	0.454
Self-media marketing	0.523	0.457	1.999***	0.552
Borrow money from family or friends	0.151	0.259	0.655*	0.382
Bank loans	0.868*	0.559	1.502*	0.798
Tax relief	0.603*	0.419	1.936**	0.833
Rent relief	−0.234	0.145	0.504	0.362
Advance goods from suppliers	−0.089	0.360	0.023	0.834
Age			0.461**	0.194
Gender			−0.261	0.193
Education			−0.088	0.142
Industry experience			1.124***	0.124
Owner' confidence in the business climate			−0.136	0.209
Type of business			0.181	0.169
Owned or leased facility			−0.797	0.399
Primary market			−0.388***	0.137
Business size			0.277**	0.118
Pre-pandemic financial condition			−0.645***	0.167
Log-likelihood	−215.883		−114.0079	
R^2	0.441		0.779	

Note: Log-likelihood and R^2 (coefficient of adjusted determination), are statistics that reflect the goodness of fit of the model; ***, $p < 0.01$; **, $p < 0.05$; *$p < 0.1$. Models are calculated in Python.

Regarding the measures taken by SMEs, whether it's tax relief, borrow money from family or friends, or online transformation, the most frequent spatial association pattern is the cluster of low values and low values, indicating that many regions have not implemented these three pandemic response measures. Furthermore, these regions have a positive spatial autocorrelation, meaning that the correlation of pandemic response measures becomes increase significant as the spatial distribution becomes more clustered. Secondly, the proportion of regions with low- and high-value clustered is also large, indicating that these regions are relatively inactive in implementing these pandemic response measures and exhibit negative spatial autocorrelation. In contrast, the regions that have implemented response measures and formed high- and high-value clustered are relatively small, and the distribution of these clustered areas across different measures exhibits significant spatial variation. Regions that have received tax relief, borrow money from family or friends, and online transformation with positive spatial autocorrelation are primarily located in the north, south, and east of the study area, respectively. This could be a potential reason for the spatial differences in post-pandemic recovery performance of SMEs across different regions.

4.3. Results of the spatial probit model

Table 6 shows the results of two sets of spatial probit models, the first excludes the control variables (model 1) and the second includes the control variables (model 2). It is essential to note that the use of the spatial probit model presupposes that there is no multicollinearity between the variables. The results of the person-correlation test for the 21 independent and control variables show that there is no significant correlation between any two variables, i.e., there is no multicollinearity. Therefore, it is appropriate to include all the independent and control variables in the spatial probit model.

It is confirmed that when the control variables are excluded in the model, only bank loans and tax relief were identified as significant factors influencing businesses' recovery performance after multiple waves of the pandemic. When the control variables are included in the model, more variables become significant factors that influence post-pandemic recovery performance of the businesses, such as self-media marketing, borrowing money from family and friends, bank loans, and tax relief. From the results of the model test statistics, Log-likelihood and R^2, it is shown that both the Log-likelihood and R^2 of model 1 are smaller than those in model 2, which indicates that model 1 fits the sample observations less well than model 2, and therefore, model 2 is better than model 1. Additionally, it suggests that, on top of businesses' responses to the pandemic, owner characteristics and business characteristics are also important factors that affect their recovery after multiple waves of pandemic. Age, industry experience, primary market, business size, and pre-pandemic financial conditions significantly affect businesses' recovery performance after the pandemic. Therefore, a business needs to consider the basic conditions of its owners and business when formulating pandemic response measures, and ignoring its own conditions, plus imitating the pandemic response measures adopted by other businesses may lead to failure.

5. Discussion

The spatial correlation of post-pandemic recovery performance of SMEs is not only varying across the macro city level, but also in the micro town or even street level. Similarly, existing studies has also reminded that spatial correlations between businesses play a key

role in post-crisis business recovery [90]. There may be two possible reasons: on one hand, the distribution of SMEs clusters that actively implement pandemic response measures exhibits significant spatial differences. Other relevant studies also emphasized that the post-crisis recovery decisions of neighboring firms are highly interdependent, which easily leads to the emergence of many small clusters with different strategies on the micro scale [91,92]. Spatial differences in pandemic response strategies may be a potential cause for the spatial correlations of post-pandemic recovery performance of SMEs to vary across different regions. On the other hand, other previous studies on businesses' survival have mentioned that neighboring businesses that provide complementary or substitute products or services can have a mutually promoting or inhibiting effect on each other's survival [44,93], leading to differences in the spatial correlation of recovery performances among SMEs in different streets or even on the same street that are close to each other.

Self-media marketing has been found to be the only factor that significantly affected the chances of recovery of businesses after the pandemic. Many studies previously conducted have qualitatively described through questionnaires that many businesses usually adopt an online business model after a pandemic [38,42,46], yet the online transformation has no significant impact on the survival rate of businesses. This result is consistent with the findings of Katare et al. [40] for small businesses in the US. Similarly, it was found that increasing the presence of a business on social media could reduce revenue loss and recovery time after a pandemic, but the online transformation does not [40]. This may be because during the pandemic, the lockdowns made it vary inconvenient for many people to socialize or play, and self-media became an important entertainment tool especially if incorporated within marketing since it could expand the quality of products or services, leading to additional income and higher chances of survival. On the contrary, although online transformation could provide courier services or an online management (thus no physical office required), the lack of effective publicity could cause a limited spread of information related to the products or services delivered, thus failing to increase incomes or to promote an efficient recovery after the pandemic. Moreover, the economic development suffered during the pandemic, and residents' sources of income were reduced, with many tightening their spending and reducing the frequency of both online and offline consumption. As a result, online operations during the pandemic did not have a significant effect on increasing business revenues and promote their recovery without vigorous promotion.

Borrowing money from family or friends has been found to facilitate the recovery of a business after multiple waves of pandemic. Many studies have proposed that the breakdown of the financial chain or the reduction of revenue are the key factors that lead to business's closure after the pandemic [4,16,40]. Thus, borrowing money from family or friends could be the fastest and most timely way to replenish funds compared to taking out a bank loan or applying for government subsidies [94], reducing the risk of closure due to financial problems.

A positive correlation has been observed between taking a bank loan and the recovery performance of businesses after the pandemic. A business's borrowing capacity is an important indicator for its ability to cope with risk [11]. Min and Huang [95] suggested that financing for business operations is one of the most important strategies to facilitate the recovery of Taiwan's tourism industry after Severe Acute Respiratory Syndromes (SARS) in 2003 [95]. Although taking a bank loan may increase the financial burden on firms [96], businesses that received bank loans during the pandemic typically had larger size or higher entrepreneurial confidence [18], which could facilitate their recovery performance after the shocks and lockdowns induced by COVID-19 pandemic.

Businesses that received tax relief had better opportunities to avoid closure than those that were not given it. Other studies have also reported a positive relationship between receiving tax relief and chances of survival after the pandemic [13,33,40]. Tax incentives such as tax rebates, subsidies or tax rate reductions are one of the important measures the Chinese government has taken to help small businesses cope with the pandemic [12]. Acquiring tax relief allows businesses to keep more funds to deal with the problems caused by the pandemic (loss of income, high prices for material and resources etc.).

Owners with higher industrial experience had better opportunities to implement the right strategies to support their businesses and their operation during difficult time. Other previous studies also suggest establishing repositories of knowledge obtained from previous disruptions as an important measure to promote business resilience [45,62,97,98], due to its importance in helping owners to make timely or correct crisis decisions [99].

SMEs that were holding a large number of employees or addressing large markets demonstrated to be facilitated in satisfying various clients and therefore incrementing, or keep sustaining, their income. Most of the existing related studies have reported a similar finding [1,15,100]. On the contrary, small businesses serving local markets were more vulnerable to crisis because they had difficulty implementing recovery strategies in multiple locations [43]. Moreover, large businesses usually have access to more resources to facilitate them recover after the crisis [45,87].

Financial conditions before the pandemic arrived also had implications. There is evidence that businesses with affluent financial conditions before the crisis had more to lose, leading them more vulnerable to the crisis [53]. However, business with good financial conditions before the crisis may be capable of getting access to abundant external resources and have more funds to accommodate new requests and limit losses [43,59] and these aspects can certain be in favor of survival and against closure.

6. Conclusions

The current study explores the spatial correlation of post-pandemic recovery performance of SMEs and identifies effective measures based on spatial probit model that can facilitate the recovery and survival of SMEs after multiple waves of shocks induced by COVID-19 pandemic. Essential datasets were obtained through two field investigations and questionnaire surveys conducted within 592 SMEs in Dongguan, China, during (July 2021) and after (July 2023) the pandemic. The current study enriches the findings of existing studies that so far ignored spatial correlations and focused only on short-term single epidemic shocks or qualitative analysis.

This work has produced three main findings.

Table 7
Summary of the findings and consequent implications.

Main findings	Implications	
	For owners of SMEs	For policymakers
The recovery performance of SMEs after the pandemic varies in spatial correlations among different local regions.	Owners need to consider the operate status of their neighboring SMEs when choosing the exact reopening time or the specific place to relocate after a pandemic shock. Moreover, these decisions should vary based on the cluster area in which an owner holds its business.	Policymakers should formulate guidelines and policies which should vary according to businesses located in different parts of the city as well as in different cities and regions.
Self-media marketing significantly affected the recovery performance of SMEs after the pandemic.	The influence of SMEs' products or services must be expanded via self-media using the entertainment plus publicity model after the pandemic shock.	N/A
Borrowing money from family or friends could facilitate the recovery of a business after multiple waves of pandemic.	Owners may consider borrowing money from family or friends to solve the pandemic-induced financial problems and support them tide over the difficulties.	N/A
Taking a bank loan is positively correlated with the recovery performance of SMEs after the pandemic.	Owners may consider taking a bank loan to solve the pandemic-induced financial problems and support them tide over the difficulties.	Implementing differentiated bank loans interest policies to promote businesses' recover based on their different characteristics.
Businesses that received tax relief had better opportunities to avoid closure than those that were not given it.	Owners may consider actively applying for tax relief to solve the pandemic-induced financial problems and support them tide over the difficulties.	Implementing differentiated tax deduction rate policies to promote businesses' recovery based on their different characteristics.
Owners with higher industrial experience had better opportunities to achieve good recovery performance after the pandemic.	Owners should pay attention to the accumulation of their industrial experience during normal operations in addition to the context of the pandemic.	N/A
Businesses with large employees or geared toward a large market could facilitate their recover after the pandemic.	Owners should pay attention to the expansion of the SMEs' scale.	N/A
Financial conditions before the pandemic had positive impact on post-pandemic recovery of SMEs.	Owners should promote performance and financial improvement during normal operations in addition to the context of the pandemic.	N/A

(1) The recovery performance of SMEs after the pandemic exhibits a positive spatial autocorrelation on the whole, however, there are significant differences in spatial correlations among different local regions.
(2) Self-media marketing, borrowing money from family or friends, requesting bank loans and tax relief are effective measures to avoid closure following a pandemic.
(3) The success of response measures to the pandemic varies with in the characteristics of both owner and business's type.

The findings of the current study provide important implications (see Table 7). For SMEs' owners, it is suggested that many operational activities must be moved online during the pandemic period, and the influence of their products or services must be expanded via self-media using the entertainment plus publicity model after the pandemic shock. Owners may consider borrowing money from family or friends, taking a bank loan or actively applying for tax relief to solve the pandemic-induced financial problems and support them tide over the difficulties. Owners need to consider the operate status of their neighboring SMEs when choosing the exact reopening time or the specific place to relocate after a pandemic shock and an owner's decision should vary based on the cluster area in which it holds its business. For example, a business located in a cluster area with extremely poor post-pandemic recovery performance should hold back its reopening time when the majority of its neighboring SMEs are poorly operated. Besides, in addition to taking the more common pandemic response measures, owners should pay attention to the accumulation of their industrial experience during normal operations, because growing it, it facilitates them to earn higher revenues and spread.

Since there may also be differences in the response measures to the pandemic by SMEs in cities of other countries, as well as complementarity or substitutability of goods or services provided by neighboring SMEs in those cities, there is the possibility of potential spatial differences in the post-pandemic recovery performances of businesses. Thus, on top of all these suggestions, policy makers should formulate guidelines and policies which should vary according to businesses located in different parts of the city, and this principle may apply to most cities around the world that have experienced pandemic lockdowns. For example, in SMEs clusters that have extremely poor post-pandemic recovery performance, policymakers should focus on building the regional business environment rather than just providing policy support to individual enterprises. In addition, the implementation of bank loans and tax relief policies can help promote businesses' recovery after multiple waves of pandemic shocks. However, the specific loan interest rate and tax deduction rate need to be differentiated according to the characteristics of different firms and owners.

Although the current study provides a quantitative analysis of long-period pandemic shocks, there are still some shortcomings that will have to be further investigated in the future. Firstly, the current study examines a sample of SMEs in one county of China, and thus these results should be compared with those related to other countries or cities in China and worldwide. Therefore, future studies should expand the study area and the sample size to get further insights associated to this context. Secondly, the current study focuses only on SMEs in the manufacturing, wholesale/retail, and service sectors, and given the possible differences in the performance of recovery associated with businesses of different sizes in different sectors after the pandemic, it is worthwhile for future research to

investigate the performance of more segmented businesses in the aftermath of the pandemic and their recovery rate. Finally, although the current study focuses on the impact of the five COVID-19 waves lasting two years, the singular rate or recovery after each single wave is ignored. Therefore, exploring even each single scenario and those in series, may lead to dissimilar and additional outcomes.

CRediT authorship contribution statement

Fan Li: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Matteo Rubinato:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis. **Tao Zhou:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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Appendix 1

Questionnaire on business operations during the pandemic

(1) What is your age?
A. 20 or below; B. 21–35; C. 36–50; D. 51 and above
(2) What is your gender?
A. Male; B. Female
(3) What is your education?
A. Primary school or below; B. Junior middle school; C. High school/junior college; D. University degree or above
(4) How many years have you operated your business?
A. Less than half a year; B. 0.5–2years; C. 2–3.5years; D. 3.5–5years; E. More than 5 years
(5) How do you think the business climate will be in the future compared to the present?
A. Much better; B. A little better; 3. About the same; 4. A little worse; 5. Much worse
(6) What is your business type?
A. Manufacturing; B. Wholesale/retail; C. Service; D. Others
(7) Is your business owned or leased facility?
A. Owned facility; B. Leased facility
(8) What is the primary market your business served?
A. National; B. Provincial; C. Municipal; D. Town; E. Local
(9) How many full-time employees does your business have?
A. 1 full-time employees; B. 2–4 full-time employees; C. 4–10 full-time employees; D. 10 or more full-time employees
(10) What was the financial condition of your business before the pandemic (before the end of 2019)?
A. Extremely good; B. Relatively good; C. Moderate; D. Relatively bad; E. Extremely bad
(11) How is your business's profitability at present compared to before the pandemic?
A. Better; B. About the same; C. Worse
(12) How many waves of pandemic lockdown (businesses in the lockdown area were required to close during the outbreak) have your business experienced during the three-year outbreak period (end of 2019 - end of 2022; round 1 roughly June 2021–July 2021, round 2 roughly August 2021–April 2022, round 3 roughly June 2022, round 4 roughly July 2022, round 5 roughly August 2022–December 2022)?
A. 5 waves and above; B. 4 waves; C. 3 waves; D. 2waves; E. 1wave; F. 0 wave
(13) Which of the following measures did you take in response to the pandemic? (Multiple choice question)
A. Layoffs; B. Technology reform and innovation; C. Online transformation (The online business model was not adopted before the pandemic, but only after.); D. Opening branches; E. Purchase of anti-pandemic materials; F. Self-media marketing; G. No measures taken

(14) Which of the following assistances has your business received in response to the pandemic? (Multiple choice question)
A. Borrow money from family or friends; B. Bank loans; C. Tax relief; D. Rent relief; E. Advance goods from suppliers; F. No assistances

Appendix 2

Statistics description for variables

Indexes	Coding scheme	Proportion (number)
Business recovery performance	0 = closed	19.4%(n = 115)
	1 = performance is worse after the pandemic than before the pandemic	33.1%(n = 196)
	2 = performance after the pandemic was like that before the pandemic	28.0%(n = 166)
	3 = performance is better after the pandemic than before the pandemic	19.4%(n = 115)
Business response measures	Whether the business has taken the following COVID-19 response measures?	
Layoffs	1 = yes	9.1%(n = 54)
	0 = no	90.9%(n = 538)
Technology reform and innovation	1 = yes	5.4%(n = 32)
	0 = no	94.6%(n = 560)
Online transformation	1 = yes	13.7%(n = 81)
	0 = no	86.3%(n = 511)
Opening branches	1 = yes	2.4%(n = 14)
	0 = no	97.6%(n = 578)
Purchase of anti-pandemic materials	1 = yes	95.6%(n = 566)
	0 = no	4.4%(n = 26)
Self-media marketing	1 = yes	8.3%(n = 49)
	0 = no	91.7%(n = 543)
Borrow money from family or friends	1 = yes	14.4%(n = 85)
	0 = no	85.6%(n = 507)
Bank loans	1 = yes	11.8%(n = 70)
	0 = no	88.2%(n = 522)
Tax relief	1 = yes	14.0%(n = 83)
	0 = no	86.0%(n = 509)
Rent relief	1 = yes	18.1%(n = 107)
	0 = no	81.9%(n = 485)
Advance goods from suppliers	1 = yes	5.2%(n = 31)
	0 = no	94.8%(n = 561)
Control variables	Owner characteristics and business characteristics	
Age	1 = 20 or below	0.5%(n = 3)
	2 = 21–35	36.3%(n = 215)
	3 = 36–50	53.2%(n = 315)
	4 = 51 and above	10.0%(n = 59)
Gender	1 = male	48.3%(n = 286)
	2 = female	51.7%(n = 306)
Education	1 = primary school or below	8.4%(n = 50)
	2 = junior middle school	40.4%(n = 239)
	3 = high school/junior college	40.9%(n = 242)
	4 = university degree or above	10.3%(n = 61)
Industry experience	1 = less than half a year' experience	0%(n = 0)
	2 = 0.5–2years' experience	7.1%(n = 42)
	3 = 2–3.5years' experience	10.3%(n = 61)
	4 = 3.5–5years' experience	29.2%(n = 173)
	5 = more than 5 years' experience	53.4%(n = 316)
Owner' confidence in the business climate	1 = extremely confident	6.1%(n = 36)
	2 = relatively confident	31.9%(n = 189)
	3 = moderate	60.2%(n = 356)
	4 = little confident	1.5%(n = 9)
	5 = no confident	0.3%(n = 2)
Type of business	1 = manufacturing	1.0%(n = 6)
	2 = wholesale/retail	54.1%(n = 320)
	3 = service	39.5%(n = 234)
	4 = others	5.4%(n = 32)
Owned or leased facility	1 = owned facility	10.5%(n = 62)
	2 = leased facility	89.5%(n = 530)
Primary market	1 = national	6.6%(n = 39)
	2 = provincial	3.7%(n = 22)
	3 = municipal	14.2%(n = 84)
	4 = town	44.6%(n = 264)
	5 = local	30.9%(n = 183)
Business size	1 = 1 full-time employees	41.6%(n = 246)
	2 = 2–4 full-time employees	24.3%(n = 144)

(*continued on next page*)

(*continued*)

Indexes	Coding scheme	Proportion (number)
	3 = 4–10 full-time employees	20.4%(n = 121)
	4 = 10–50 full-time employees	13.7%(n = 77)
Pre-pandemic financial condition	1 = extremely good	4.7%(n = 28)
	2 = relatively good	43.6%(n = 258)
	3 = moderate	45.1%(n = 267)
	4 = relatively bad	5.7%(n = 34)
	5 = extremely bad	0.9%(n = 5)

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