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The challenges of COVID-19 control policies for sustainable development of business: Evidence from service industries

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ABSTRACT

Such large-scale disruptions as the pandemic increase the uncertainty and risk related to business. Therefore, the business continuity management (BCM) has become an essential technical solution for enterprise emergency response. Since the beginning of 2020, the COVID-19 has spread worldwide at an alarming rate causing many threats to sustainable development of the business sector. The decline in consumer demand has hugely impacted service industries, such as wholesale and retail sales, tourism. Enterprise production and operations have faced severe challenges. In this study, we develop a risk factor analysis of BCM under the presence of COVID-19 in China. Based on a statistical survey of 940 enterprises in Hangzhou City, China, this study employs ordinal logistic regression to explore the hindering effect of risk factors introduced by the epidemic on business performance. Then, the interpretive structure model (ISM) is applied to analyze the hierarchical structure of the factors under examination. The key factors influencing the enterprise production and operation during COVID-19 outbreak significantly differ across the sub-sectors of the service industry. Therefore, this paper assesses the resilience of the productive technologies and business models of different industries amid the pandemic. This paper proposes epidemic prevention and control strategy focusing on investment and government regulation to ensure sustainable business development.

1. Introduction

Sustainable development of business is necessary to achieve sustainable development goals for economies [1]. Therefore, as business is the key driver of economic development of countries, the state policies creating favorable environments for business operations are necessary in order to mitigate negative impact of business threats on sustainable development of the country [2,3]. The main global risks first of all hit business and then create a lot of problems in public sector as well. Following the emergence of COVID-19 in China at the end of 2019, the outbreak had spread widely by early 2020. The World Health Organization listed it as a public health emergency of international concern on January 30th. According to the data updated by the World Health Organization on July 13th, 2020, COVID-19 has spread to over 200 countries, and the United States and South America have become new international epidemic centers. At the time of writing, nearly 12, 947, 601 cases of infection have been recorded in the world, and approximately 566,703 infected individuals have died of pneumonia infection.

The normal global economic order and social stability which are the main goals of sustainable development are confronting severe challenges. The health threats have affected operation of both public and private domains [4–6].

While countries have generally strengthened prevention and control measures against COVID-19, their normal production operations have been affected causing a lot of threats to business and hampering sustainable development of the countries. During the initial outbreak of COVID-19, enterprises were unable to operate normally, resulting in a decline in revenue, increased pressure from rising costs, and cash flow difficulties. During the mitigating period of the epidemic, enterprises must still confront issues stemming from restricted operating factors and insufficient implementation of prevention and control measures, and may continue to face operational difficulties in the long run and other dangers to their sustainable development.

Since most business activities conducted by service enterprises primarily embarking on in-person customer service, the epidemic’s negative impact on these types of companies is particularly serious [50]. Let
we take the hospitality and catering industry as an example. According to the “China Economic Observation 2020 (Second Quarter)” that was released by KPMG, the added value of China’s accommodation and catering industry dropped significantly in the first quarter by 41.3% year-on-year. Thus, it is important to assess the operation of the business activities for a given technology in the context of disruptions rendered by external shocks. The COVID-19 pandemic is the most recent example of overwhelming disruptions challenging the continuity of the production process and requiring the adaptation of the production technology to the societal demands [7].

Clarifying the key factors related to COVID-19 that affect service enterprise production, operations and sustainable development will help government departments to formulate industrial support policies, promote the recovery of enterprise production and operations activities, ensure the effective supply of materials for epidemic prevention and control, and create a better environment for policy implementation. To this end, we selected 940 service enterprises in Hangzhou, China, and conducted a survey from February 2020 to July 2020. Analyzing the everyday business operations during the prevention and control of COVID-19 will hopefully enable the plight of service enterprises in production and operations to be clarified, as well as explain the impact on business performance and sustainable development caused by public health events from a micro perspective.

This research aims to draw on risk identification theory from the field of business continuity management [8], and divide enterprises’ operating risks into the categories of market, supply chain, internal enterprise, and external environmental risks based on their quantitative identification, and then discuss the micro-transmission mechanism of COVID-19’s impact on the production, operations and sustainable development of the enterprise. Through the further subdivision of the service industry, this study will first explain whether differences are revealed in the main factors affecting business recovery and sustainable development possibilities between the various sub-sectors, and will then propose more targeted and operational policy recommendations accordingly.

The remainder of this article is organized as follows: Section 2 contains the literature review, which identifies risk factors confronted by the economy due to catastrophic events and epidemics. In Section 3, we establish the theoretical framework, which is focused on how COVID-19 affects the performance of service enterprises, and will then introduce the observation variables selected for this article. Section 4 presents the research design, which mainly introduces the sample’s distribution characteristics, the descriptive statistics of the survey questions, and the model used for analysis in this study. Section 5 presents an empirical analysis, which quantitatively measures the impact of various risk factors on enterprise production, operations and sustainable development from the perspective of whole and sub-industries. Conclusions and related recommendations are summarized in Section 6.

2. Literature review

COVID-19 has adversely affected almost all industries worldwide [9–11]. Compared to agriculture, manufacturing, and other industries, the service industry has been affected more negatively, especially sub-sections or entities within the industry that are unable to conduct online transactions. The query on “COVID-19 AND business” in the Web of Science database returned 757 references as of December 2020. The map of keywords based on the results from the query is provided in Fig. 1.

The keyword map in Fig. 1 implies that the research on the business operation amid the COVID-19 is multifaceted. The issues purely related to business include business strategy, capabilities, recovery, and vulnerability. Another closely related cluster of keywords relates to the managerial practices: intention, adoption innovation, business models and sustainability. The next group of keywords defined the sectors that are industry, restaurants, airlines. The societal effects include entrepreneurship, crisis, performance, employment and growth. The context correlates are also represented as a group of factors. Psychological issues are clustered as well and include public health, dynamics, mobility, epidemiology, mental health, social distancing, anxiety. This map of

![Fig. 1. The keywords related to research on COVID-19 and business in the Web of Science database.](image-url)
keywords implies that both social and economic factors are closely interrelated and are likely to affect business performance amidst the COVID-19 pandemic.

The discussed interrelationships are also evident in the co-citation map for the journals publishing paper on business and COVID-19. The six groups of journals emerge in Fig. 2. The medicine journals (e.g., Lancet, Science) and popular outlets (e.g., The Guardian, New York Times) appear in the best-represented cluster. Then, there are two groups of journals related to sustainability issues and tourism economics (Sustainability, Journal of Business Ethics, Journal of Cleaner Production, Business Strategy and the Environment, Tourism Management, Journal of Air Transportation Management, Journal of Service Management). The remaining three groups of journals are related to economics and management. The journals related to production economics are represented by Supply Chain Management, International Journal of Production Research, International Journal of Production Economics. The mainstream economic journals related to COVID-19 and business are Journal of Financial Economics and American Economic Review. The journals from the area of management are Academy of Management Review, Entrepreneurship Theory and Practice, Organization Science. Obviously, this pattern of interlinked journals represents the complexity of the business operation amid the COVID-19 once again.

When discussing the impact of public events on enterprises, most existing literature focuses on the impact of catastrophic events (such as typhoons, floods, earthquakes, etc.) on the economic environment, the industry, and the recovery capabilities of small and medium-sized enterprises (SMEs) [12–14]. Business continuity management theory (BCM) is widely used to construct a theoretical analysis framework to research the post-disaster recovery of enterprises.

Based on BCM theory, Sydnor et al. [15] believe that catastrophic events will affect most business entities, the impact of which can be divided into direct and indirect aspects. Among these, the direct impact category includes casualties and disaster losses, while that of the indirect impact mainly includes business reduction and infrastructure disruption. Silva [16] pointed out that catastrophic events may also cause certain risks for the enterprise’s supply chain, which are manifested in the interruption of the production and supply chain, delayed payment by customers, and employees’ inability to resume work. Undoubtedly, a catastrophic event poses a huge challenge to the continuity of an enterprise’s production and operations. However, it is noteworthy that the impact of catastrophic events on enterprises differs based on a given enterprise’s size and industry. Koerniadi et al. [17] pointed out that large enterprises typically experience a faster recovery speed, and insurance and real estate companies have more advantages in business recovery and higher possibilities for sustainable growth than those in the tourism and retail industries.

The epidemic situation and subsequent impact of COVID-19 have become the focus of academic research as the most significant catastrophic current event. Overall, the outbreak of COVID-19 has had a major impact on the macro-economy: first, a "cliff decline" in social demand occurred; second, a significant negative impact on investment, export, and consumption demand was observed; and third, social employment and price levels fluctuated significantly [9,11]. For enterprises, the continued spread of the epidemic has restricted the population’s freedom of movement, greatly reduced consumers’ enthusiasm for consumption, and sharply reduced the market demand [18,19]. Widespread shutdown and logistics control are currently hindering the supply of raw materials and products along the entire industrial chain, which affects production supply for the entire society [20]. Atalan [21] believes that a certain degree of isolationist policy has caused many enterprises to remain in semi-shutdown or maintain low-level operations for a long period, and production and operations have consequently confronted extreme difficulties.

Recently, Chinese scholars have conducted further discussions on the production and management issues enterprises have encountered against the background of COVID-19, and the related achievements primarily relate to two aspects. On the one hand, current discussions summarize the numerous difficulties faced by enterprises, such as higher costs, a shortage of funds, and uncoordinated supply chains [20,49]; on the other hand, scholars have discussed the policies necessary for enterprise production and operations, such as those related to finances and tax, financial supply, and tax preferences [22]. Through a successive survey of SMEs, Zhu et al. [23] conduct a concrete analysis of policy implementation and the rationale for any deviation to provide continuous policy support. Researchers are also aware of the need for different policy guidance for enterprises of different sizes and industries. Zhang [24] surveyed 116 SMEs and found that COVID-19’s impact varies based on the type of enterprise, and differences in policy requirements were also observed. Huang et al. [25] investigated the impact of COVID-19 on expectations related to enterprise development based on the pressure conduction mechanisms. The results reveal a statistically significant difference in the expectations of different types of enterprises. Moreover, Liu et al. [26] analyzed the economic impact of COVID-19 based on an input-output analysis framework. According to the impact

![VOSviewer](https://example.com/vosviewer.png)

Fig. 2. The journals related to research on COVID-19 and business in the Web of Science database.
characteristics, several policy recommendations were then put forth.

In summary, COVID-19’s impact on enterprise production and operations is multifaceted. Many studies have explained the factors of enterprise performance amid the pandemics, developed empirical research based on theoretical models, and delivered the corresponding policy recommendations. We further focus on the enterprise performance in China during the pandemic.

3. Theoretical analysis and selected variables

3.1. Concept of business continuity management

According to the ISO22312:2011 Societal Security-Technological Capabilities, BCM is an emergency risk management process that can identify the uncertain risks confronted by enterprises during emergencies, as well as their impact on business processes and sustainable growth opportunities, and then provide appropriate suggestions that support the management of key elements to further reduce the impact of emergencies on enterprises and accelerate business recovery.

Among them, business impact analysis is a key step in BCM, which Tan et al. [31] defined as “the process of analyzing the risks that may arise in the event of an emergency.” In this article, we regard COVID-19 as a destruction risk, as it triggers a series of operational risks in enterprises’ production and operations process, which impacts business continuity and sustainable development.

Due to the deep uncertainty characterizing the operational risk caused by COVID-19, enterprises’ production and operations processes are also confronting significant uncertainty in the current period of epidemic prevention and control. March and Shapira [29] stated that “risk is uncertainty regarding the possible outcome of an event.” In an effort to explain the source of risk due to uncertainty, Beyer et al. [30] believe that this type of risks caused by the external environment, production inputs and outputs, and internal feasibility. Based on the perspective offered by BCM, Tan et al. [31] defined operational risk based on the condition of production business, asserting that it mainly comprises risks related to internal decision-making risks and production and supply risks.

According to the uncertainty theory discussed by Beyer et al. [30]; the definition of operational risk by Tan [31]; and also drawing on the research of Torabi et al. [8] regarding the perspective offered by the enterprise business process, we organize the sources of uncertain factors related to enterprise operations during COVID-19 into four types of risk: market, supply chain, internal, and external risk. This paper constructs a theoretical framework comprising the factors of uncertainty that affect the operation and management of enterprises under COVID-19, which is presented in Fig. 3.

3.2. Factor explanation and variable selection

The uncertain risk elements in Fig. 3 warrant further explanation. Thus, when designing the corresponding questionnaire, these factors of uncertainty are converted into measurable variables to carry out the empirical analysis. The risk factors in Fig. 3 are defined as follows:

Market risk. Alongside the epidemic outbreak, the market demand will undergo major structural changes in the short term and the demand for basic household goods and medical supplies will increase substantially; meanwhile, the demand for other non-essential items will decrease. Generally, during the period of epidemic prevention and control, residents’ consumption willingness has shown a steep decline. For enterprises in industries with weak demand, it is necessary to adjust business sustainable development strategies in a timely manner in accordance with the level of demand.

Supply chain risk. Logistics and transportation provide necessary external support for enterprises. After the epidemic outbreak, to prevent its rapid spread, most governments across the globe have taken relevant measures to strictly control local traffic logistics. In this case, most enterprise supply chain circulation systems have fallen into a state of passive paralysis. The supply chain that connects raw materials, middlemen, and terminal sales has been forced to “shut down”; therefore, both upstream and downstream enterprises in the supply chain have been unable to resume production smoothly, which has resulted in economic losses [32]. Therefore, upstream and downstream enterprises in the supply chain must cooperate to avoid the risk of a supply chain collapse and ensure that enterprises can resume normal operations as soon as possible. Similarly, sustainable supply chain management (SSCM) technical program [33] has also received more attention in the domain of enterprise management.

Internal risk. In this article, internal risks primarily reference the feasibility conditions under which enterprises may resume production and operations. Human capital is a key asset of an enterprise, and employees are the most direct victims of COVID-19. The struggles encountered by the labor force, which is suffering from isolation, casualties, and even death during the epidemic, have caused a labor shortage to a certain extent, which undoubtedly affects enterprise production and operations [34].

Meanwhile, during the epidemic, enterprise shutdowns have led to a sharp decrease in operating income while comprehensive costs (including employee wages, loan interest, housing rent, and epidemic cost) have increased sharply.

External risk. In this article, external risks primarily reference the external environment, which may cause business interruption or expand business opportunities. The epidemic has caused a sharp decrease in consumer willingness. Meanwhile, enterprises are facing the challenges of rising costs and reduced demand. Enterprises must make the right decisions to fulfill the market needs and increase their competitiveness. The uncertainty of the external environment is hence defined as external risk, which can be divided into the following two types: consumption willingness and policy environment change.
policies to alleviate the operational difficulties confronted by enterprises during the process of resuming production and operations. External Risk. External conditions primarily reference the policy environment confronted by enterprises. Fakhruddin et al. [36] believe that only when governments of various countries seriously evaluate the reality of COVID-19, which is the main prerequisite for truly achieving epidemic prevention and control. During the period of COVID-19 prevention and control, the Chinese government implemented several policies to alleviate the operational difficulties confronted by enterprises, such as the reduction and exemption of tax payments, loan discounts, and financial subsidies, which have achieved remarkable results. Based on the explanation of the uncertain risk factors mentioned above, we designed relevant variables for use in the quantitative analysis, and implemented them in the questionnaire. The relationship between uncertain risk factors and variables is shown in Table 1. To facilitate comparison with the relevant literature, we also present the variables used in similar studies in Table 1.

4. Data and methods

4.1. Descriptive statistics

We designed a questionnaire and conducted a survey that was administered to enterprises. The questionnaire comprises five aspects: production and operations, employment, capital, logistics, and government services. A total of 942 questionnaires were completed. After excluding any questionnaires that were missing data, 940 valid questionnaires were obtained with an effective response rate of 99.8%.

In terms of industry distribution, the sampled companies are mainly concentrated in the fields of wholesale and retail sales, cultural tourism, and information services. According to the survey data (Table 2), the status of their production and operations can be divided into four categories: good, moderate, poor, and not be resumed, with proportions of 4.8%, 23.4%, 32.1%, and 39.7%, respectively. Most companies participating in the survey stated that they faced operational risks, especially in terms of poor logistics, cash flow difficulties, and labor shortages. The policies sought by companies are mainly focused on coordinating the control of transportation and deferring taxes and fees.

4.2. Methods

4.2.1. Ordinal logistic regression

Logistic regression is typically used to evaluate the influence of a set of variables on the selection probability of a certain alternative, especially for factors that affect a given decision but cannot be directly observed. In the analysis of factors affecting business operations, the important influencing factors include logistics, supply chain, and market demand. However, these variables typically cannot be observed directly, and can only be quantified by constructing dummy variables. Meanwhile, changes in enterprise operations during the epidemic have been ordered sequentially; thus, ordinal logistic regression is a more relevant method.

To examine COVID-19 impact on the production and operations of service industry enterprises, we construct the linear model:

$$z = \beta S_i + \epsilon_i$$  \hspace{1cm} (1)

where $z$ represents the dependent variable, i.e., the business condition (BC); $S_i$ is a vector of the explanatory variables, and includes market demand (MD), logistics (LOG) etc.; $\beta$ represents the parameters to be estimated and $\epsilon_i$ is the random error term. Since variable $z$ is a categorical one, the survey data can be converted as defined by Liu et al. [41]. The specific rules are listed in Table 3 ($\mu_i$ is the threshold for enterprise business conditions).

Therefore, the probability that an enterprise’s operations belong to a certain category can be calculated as

$$P(S_{BC} = i) = \Lambda(\mu_i - \beta S_i) - \Lambda(\mu_{i-1} - \beta S_i)$$  \hspace{1cm} (2)

where $\Lambda(\cdot)$ denotes the standard logarithmic cumulative distribution function. The logarithmic maximum likelihood estimation is used to estimate the parameters in Eq. (2). The likelihood function used in the ordinal logistic regression is

$$LL = \sum_{n=1}^{N} \sum_{i=1}^{I} LN[\Lambda(\mu_i - \beta S_i) - \Lambda(\mu_{i-1} - \beta S_i)]y_{in}$$  \hspace{1cm} (3)

where $y_{in} = 1$ if observation $n$ belongs to $\mu_i$ and $y_{in} = 0$ otherwise. After obtaining the estimates of $\beta$, Eq. (3) can be transformed into

$$P(S_{BC} = i) = \frac{\exp(\beta S_i + \beta S_i)}{1 + \exp(\beta S_i + \beta S_i)}$$  \hspace{1cm} (4)

The odds ratio can then be presented as

| Variable                  | Notation | Definition                                                                 | Reference |
|---------------------------|----------|-----------------------------------------------------------------------------|-----------|
| Nature                    | IND      | Cultural tourism = 1; Wholesale & retail sales = 2; Information services = 3; | [37]      |
|                           |          | Transport logistics = 4; Real estate = 5; Financial services = 6; Business services = 7; Community services = 8; Other = 9 | [38]      |
| Operations                | BC       | Not be resumed = 1; Poor operation = 2; Moderate operation = 3; Good operation | [39]      |
| Market risk               | MD       | Decline in market demand = 1; Otherwise = 0 | [40]      |
| Customer churn            | CC       | Order loss = 1; Otherwise = 0 | [41]      |
| Supply chain risk         | LOG      | Logistics restriction = 1; Otherwise = 0 | [42]      |
| Internal risk             | LF       | Labor shortage = 1; Otherwise = 0 | [43]      |
| Prevention materials      | CF       | Insufficient cash flow = 1; Otherwise = 0 | [44]      |
| Cost pressure             | CP       | Great cost pressure = 1; Otherwise = 0 | [45]      |
| External risk             | DTF      | Policy support = 1; Otherwise = 0 | Some policies to support the production and operation of enterprises |
### Table 2

Distribution of the variables used in the study.

| Variable              | Level          | Frequency | Variable              | Level          | Frequency |
|-----------------------|----------------|-----------|-----------------------|----------------|-----------|
| Industry (IND)        | Cultural tourism | 174 (18.5%) | Business Conditions (BC) | Not be resumed | 373 (39.7%) |
|                       | Wholesale & retail sales | 112 (11.9%) | Poor operation | 302 (32.1%) |
|                       | Information services | 164 (17.4%) | Moderate operation | 220 (23.4%) |
|                       | Transport logistics | 82 (8.7%) | Good operation | 45 (4.8%) |
|                       | Real estate | 88 (9.4%) | Prevention materials (PM) | Shortage | 273 (29.0%) |
|                       | Financial services | 77 (8.2%) | Otherwise | 667 (71.0%) |
|                       | Business services | 83 (8.8%) | Cost pressure (CP) | Great pressure | 470 (50.0%) |
|                       | Community services | 52 (5.5%) | Otherwise | 470 (50.0%) |
| Market demand (MD)    | Decline | 416 (44.3%) | Deferral of taxes and fees (DTF) | Need support | 626 (66.6%) |
|                       | Otherwise | 524 (55.7%) | Discount loan (DL) | Need support | 258 (27.4%) |
| Customer churn (CC)   | Order loss | 246 (26.2%) | Otherwise | 682 (72.6%) |
|                       | Otherwise | 694 (73.8%) | Compensation fund (COF) | Need support | 271 (28.8%) |
| Logistics (LOG)       | Restriction | 851 (90.5%) | Otherwise | 669 (71.2%) |
|                       | Otherwise | 89 (9.5%) | Coordinated transportation (COT) | Need support | 227 (24.1%) |
| Supply chain (SC)     | Incoordination | 263 (28.0%) | Otherwise | 271 (28.8%) |
|                       | Otherwise | 677 (72.0%) | Provide prevention materials (PPM) | Need support | 484 (51.5%) |
|                       | Otherwise | 190 (20.2%) | Simplify the resumption of approval process (SRP) | Need support | 212 (22.6%) |
| Cash flow (CF)        | Insufficiency | 856 (91.1%) | Otherwise | 728 (77.4%) |
|                       | Otherwise | 84 (8.9%) |

### Table 3

Mapping rules for variable $z$.

| Level                  | Definition                  |
|------------------------|-----------------------------|
| Not be resumed         | $S_{BC} = 1$, if $z \leq \mu_1$ |
| Poor operation         | $S_{BC} = 2$, if $\mu_1 < z \leq \mu_2$ |
| Moderate operation     | $S_{BC} = 3$, if $\mu_2 < z \leq \mu_3$ |
| Good operation         | $S_{BC} = 4$, if $z > \mu_3$ |

$$P(S_{BC} = i) = \frac{1}{1 - P(S_{BC} = i)} = \exp(\beta_i + \beta_S) = e^{I}(\beta_S)^i$$

(5)

#### 4.2.2. ISM model

After confirming the key influencing factors, to further explain the micro-conductive pathway by which COVID-19 affects enterprise operations, we adopt the ISM to conduct subsequent analysis. In the ISM framework, directed graph, matrix, and computer techniques are used to handle various types of information (such as elements and their correlations, which are then distinguished into different levels), which are ultimately transformed into a hierarchical structure to reveal the hierarchy and overall structure comprising all factors. 42.

The main steps of the ISM model are described as follows:

**Step 1.** First, the logical relationship between key elements is determined. Let $S_{BC}$ represent the business conditions of service enterprises in the sample, while $S_i$ (such as $S_{MD}$) represents the statistically significant factors obtained from the ordinal logistic regression. The logical relationship between these factors is determined via an evaluation conducted by experts.

**Step 2.** An adjacency matrix of the factors is constructed. Based on the logical relationship among the various factors, we can establish an adjacency matrix $A = [a_{ij}]_{k \times k}$, where $a_{ij}$ is defined as:

$$a_{ij} = \begin{cases} 1, & S_i \text{ is related to } S_j, \\ 0, & S_i \text{ is not related to } S_j, \end{cases} \quad 1 \leq i, j \leq k$$

(6)

**Step 3.** A reachability matrix of the factors is established. Using Eq. (7), the reachability matrix $M$ can be obtained by transforming the adjacency matrix $A$.

$$M = (A + I)^r = (A + I)^{r-1} \neq (A + I)^{r-2} \neq \ldots \neq (A + I)^2 \neq (A + I), \quad 2 \leq r \leq k.$$

(7)

where $I$ represents a unit matrix. The calculation process can be conducted using related software, such as MATLAB, and the result can be expressed as $M = [m_{ij}]_{k \times k}$.

**Step 4.** The reachability matrix is divided into the reachable sets $P(S_i)$ and antecedent sets $Q(S_i)$, and the definitions can be expressed as Eqs. (8) and (9), respectively.

$$P(S_i) = \{m_{ij} = 1 | S_j\}$$

(8)

$$Q(S_i) = \{m_{ij} = 1 | S_j\}$$

(9)

where $P(S_i)$ represents the set of corresponding column factors when the value of the element is equal to 1 in the $i$th row of the reachability matrix. $Q(S_i)$ represents the set of corresponding row factors when the value of the element is equal to 1 in the $j$th column of the reachability matrix. $\{m_{ij} = 1 \mid S_j\}$ represents the set of column elements when the condition is met, and $\{m_{ij} = 1 \mid S_j\}$ represents the set of row elements when the condition is met.

**Step 5.** The hierarchy of factors $C_t (1 \leq t \leq k)$ is constructed using a stepwise decomposition method. First, the intersection of the reachable set $P(S_i)$ and set $Q(S_j)$ is solved, and the elements in the intersection are classified as first-level factors $C_t$. The formula can be expressed as follows:

$$C_t = \{P(S_i) \cap Q(S_j)\}$$

(10)

Second, in the reachability matrix $M$, the rows and columns corresponding to each element in $C_t$ are deleted to obtain a new reachability matrix $M_t$. Steps 4 and 5 are repeated to obtain all clusters $\{C_t\}$; we then obtain a factor chain with a logical relationship, which is the hierarchy of factors.
5. Results

5.1. Cross-analysis between enterprise characteristics and operations

Koerniadi et al. [17] believe that the state of an enterprise’s production and operations is the performance obtained after the enterprise comprehensively considers various risk factors and makes corresponding decisions, and is therefore closely related to certain enterprise characteristics.

To examine the correlation between industry characteristics and an enterprise’s operating status, we conducted a cross-tabulation analysis. The results show that the operating status of an enterprise varies by industry, and the difference is significant at a statistical level of 1% (see Table 4 for details).

Further analysis found that in industries such as cultural tourism, wholesale and retail sales, and real estate, due to the reduction in consumer demand, the probability that enterprises will resume production and operations is relatively low. Due to the urgent necessity of preventing and controlling COVID-19, in the information services, logistics transportation, and financial service industries, the probability that enterprises will return to production is relatively high, but the operating situation is still not optimistic. Therefore, this difference in the operational status of various industries demonstrates that we must conduct an analysis from the perspective of specific industries while also explaining the model holistically.

5.2. Empirical analysis of influencing factors

In this study, we use SPSS 20.0 to build an ordinal logistic regression model for the sample data, the results of which are shown in Table 5. Before running the ordinal logistic regression model, it is necessary to verify whether multicollinearity is present between the independent variables [43]. The results of the linearity test show that the variance inflation factor is less than 10 and indicate that no collinearity is present among the variables in the model.

Second, the parallel line assumption and the goodness of fit test are needed to determine the applicability of this model. The results show that the p-value of the parallel line assumption is 0.312 > 0.05, which means that the model satisfies the parallel line assumption; therefore, the ordinal logistic regression can be used as an analysis method. The p-value of the goodness of fit test is 0.000 < 0.01, thus indicating that the fitting effect is good.

We collate the estimated results of the ordinal logistic regression in Table 5. The results show that eight factors, including market demand (MD), logistics (LOG), supply chain (SC), labor force (LF), cash flow (CF), deferral of taxes and fees (DTF), coordination of transportation (COT), and simplifying the resumption of the approval process (SRP) have a statistically significant impact on enterprise operations.

Market Risk. The change in the market demand (MD) has a significant negative impact on enterprise operations. Specifically, under the condition of reduced market demand, it is less likely that enterprises will resume production and operations (exp(β_MD) = 0.581, p < 0.000). Therefore, if the market demand is suppressed, even if an enterprise consumes significant resources to realize the resumption of its production, its products and services cannot be immediately sold, which problematizes its ability to maintain a balance between costs and benefits. As a result, it is impossible for enterprises to restore their operating status to the level at which it functioned before the outbreak of COVID-19 in a short period [44].

Supply Chain Risk. Restricted logistics (LOG) and an uncoordinated supply chain both upstream and downstream (SC) have a significant negative impact on enterprise production and operations, but in terms of the degree of impact, the latter is slightly smaller than the former (β_LOG = −0.599 < β_SC = −0.361). The data show that enterprises with limited supply chain logistics are only 0.549 times more likely to resume production than those with smooth supply chain logistics (exp(β_LOG) = 0.549, p = 0.000). The resources and channels necessary for normal enterprise operations can only be guaranteed through collaboration with relevant enterprises along the supply chain. If supply chain logistics is restricted, enterprises will struggle to carry out production and operations.

Internal Risk. The aspects of the labor force (LF) and cash flow (CF) also restrict the operation of service industry enterprises. The

### Table 4
Relationship between enterprise characteristics and operations.

| Industry (IND)            | Business Conditions (BC)          | Not be resumed | Poor operation | Moderate operation | Good operation | Pearson χ² | Sig |
|---------------------------|----------------------------------|----------------|----------------|-------------------|----------------|------------|-----|
| Cultural tourism          |                                 | 65.5%          | 23.0%          | 8.6%              | 2.9%           | 109.864    | 0.000*** |
| Wholesale & retail sales  |                                 | 41.1%          | 31.3%          | 25.0%             | 2.7%           |            |     |
| Information services      |                                 | 36.6%          | 37.8%          | 24.4%             | 3.7%           |            |     |
| Transport logistics       |                                 | 24.4%          | 47.6%          | 24.4%             | 3.7%           |            |     |
| Real estate               |                                 | 45.8%          | 20.3%          | 30.5%             | 3.4%           |            |     |
| Financial services        |                                 | 16.4%          | 29.1%          | 41.8%             | 12.7%          |            |     |
| Business services         |                                 | 40.3%          | 31.9%          | 20.8%             | 6.9%           |            |     |
| Community services        |                                 | 50.0%          | 12.5%          | 18.8%             | 18.8%          |            |     |
| Other                     |                                 | 28.6%          | 35.4%          | 29.1%             | 6.8%           |            |     |

Note: ***, **, and * are significant at the 1%, 5%, and 10% levels, respectively.

### Table 5
Ordinal Logistic Regression estimates of the factors affecting enterprise operations.

| Variable | B     | S.E.   | Wald   | Sig          | Exp(B) |
|----------|-------|--------|--------|--------------|--------|
| Market   | MD    | −0.543 | 0.129  | 17.591       | 0.000*** | 0.581   |
| Risk     | CC    | −0.159 | 0.144  | 1.219        | 0.270   | 0.853   |
| Supply Chain | LOG  | −0.599 | 0.178  | 11.263       | 0.001*** | 0.549   |
| Risk     | SC    | −0.361 | 0.144  | 6.274        | 0.012** | 0.967   |
| Internal | LF    | −0.447 | 0.148  | 9.135        | 0.003*** | 0.640   |
| Risk     | CF    | −0.013 | 0.167  | 0.007        | 0.956   | 0.987   |
| PM       | CP    | 0.22   | 0.131  | 2.81         | 0.094*  | 0.803   |
| DTF      | DL    | −0.332 | 0.14   | 5.638        | 0.018** | 0.717   |
| COT      | PPM   | −0.028 | 0.134  | 0.044        | 0.834   | 0.972   |
| SRP      | 0.654 | 0.156  | 17.581 | 0.000***     | 1.923   |

Note: ***, **, and * are significant at the 1%, 5%, and 10% levels, respectively.
probability that enterprises will resume production with an insufficient labor force is only 0.64 times that of enterprises with a sufficient labor force ($\exp(\beta_{LF}) = 0.64, p = 0.003$). In addition, cash flow guarantees an enterprise’s normal operations following a disaster, at which time staff management and improve productivity rely heavily on funds [45]. The results of the regression reveal that enterprises with insufficient cash flow are less likely to resume production and operations ($\exp(\beta_{CF}) = 0.472, p = 0.000$).

**External Risk.** Deferral of taxes and fees (DTF) and coordinating transportation policies (COT) negatively impact enterprise operations. Here, it is noteworthy that this negative impact contrasts with the other risk variables above. This contrast occurs because it represents the degree of demand for an enterprise. In other words, enterprises that have not resumed production hope to be supported by these two major policies: deferred taxes and fees and coordinated transportation ($\exp(\beta_{DTF}) = 0.717, p = 0.018\exp(\beta_{COT}) = 0.751, p = 0.049$), and the demand for the former is higher than that for the latter ($\beta_{DTF} = -0.332 < \beta_{COT} = -0.287$). The policy regarding simplifying the resumption of the approval process (SRP) is less urgent because enterprises that have not yet resumed production have not experienced a rigorous approval process ($\exp(\beta_{SRP}) = 1.923, p = 0.000$).

### 5.3. Interpretive structure analysis

According to the results regarding the fitness of the regression model, the significant factors affecting enterprise production and operations during the prevention and control of COVID-19 have been confirmed. Although the ordinal logistic regression model can determine the significant influencing factors, it cannot obtain the hierarchical structure that is formed by the significant variables. Therefore, the ISM model is used to further determine the relationship and hierarchical structure among the eight factors.

For convenience of presentation, $S_i$ is used to represent the explained variables and significant factors in this paper, which are as follows: the business conditions ($S_{BC}$), market demand ($S_{MD}$), logistics ($S_{LOG}$), supply chain ($S_{SC}$), labor force ($S_{LF}$), cash flow ($S_{CF}$), deferral of taxes and fees ($S_{DTF}$), coordination of transportation ($S_{COT}$), and simplifying the resumption of the approval process ($S_{SRP}$).

All variables are arranged into a matrix of nine rows and nine columns and draw on the experience and knowledge of experts to determine the logical relationship between the factors (see Fig. 4). Three logical relationships exist between the variables: $V$ indicates that an element in a row affects that of a column, $A$ indicates that an element in a column affects that of a row, and $O$ indicates that no relationship exists between a row and a column.

According to the basic steps required for the ISM model (see Section 4.2.2 for details) and using MATLAB package, the hierarchical structure is obtained. The eight significant factors are divided into four levels as follows: $L_1 = \{S_{BC}\} L_2 = \{S_{DTF}, S_{COT}, S_{SRP}\} L_3 = \{S_{MD}, S_{LOG}, S_{LF}, S_{CF}\}$, and $L_4 = \{S_{LOG}\}$. To further observe the logical hierarchical between these factors and based on the hierarchical division of the reachability matrix, a multi-level recursive graph can be obtained, as shown in Fig. 5.

As shown in Fig. 5, the policy support for deferral of taxes and fees (DTF), coordinating transportation (COT), and simplifying the resumption of the approval process (SRP) are the surface factors. Market demand (MD), supply chain (SC), labor force (LF), and cash flow (CF) are the indirect factors. Logistics (LOG) is a deep factor that affects enterprise operations. These results are consistent with the conclusions of Holguin-Veras et al. [46]. Based on the meta-analysis of interviews with the victims of an earthquake in Northeast Japan and related news materials, Holguin-Veras et al. [46] believe that logistics and transportation factors play an extremely important role during the post-disaster recovery period. The more optimized the logistics system, the higher the mobility of resources, and the faster the reconstruction or recovery of the areas affected by the disaster; thus, the importance of the logistics system is self-evident.

Market demand (MD), supply chain (SC), labor force (LF), and cash flow (CF) are intermediate factors that affect enterprise operations. Cash flow has a certain independent influence, while market demand, supply chain, and labor force are nodes that connect deep and surface factors, and play a key intermediary role. Wang [47] argues that as logistics and transportation are a necessary link in supply chain management, focus should be placed on the needs of downstream customers and all links in the supply chain should be integrated to achieve efficient operations. Therefore, during the prevention and control of COVID-19, strict traffic control inevitably has a negative impact on the supply chain, which affects enterprise production and operations.

In general, formulating corresponding policy guidelines is the most effective means of resolving the plight of enterprises in the short term. Therefore, policies such as deferring taxes and fees (DTF), coordinating transportation (COT), and simplifying the resumption of the approval process (SRP) have a direct impact on enterprise production and operations, and can be deemed surface-factors. However, enterprises'
recovery of operations cannot rely solely on government policies. In the long run, issues in supply and logistics are the root cause of the problem.

5.4. Industry-specific heterogeneity of factors

The analysis results in Table 4 show that industry attributes are significantly related to enterprise production and operations during the prevention and control of COVID-19. Industries such as cultural tourism, wholesale and retail sales, information services, logistics, and transportation are the primary sectors affected by COVID-19. However, certain differences exist between these industries in terms of the main factors affecting the recovery of enterprise production and operations. Therefore, we applied an ordinal logistic regression model to conduct empirical analysis. Table 6 shows the corresponding results.

As seen in the first column in Table 6, the factors that significantly affect (p < 0.05) operations in the cultural and tourism service industries are mainly market demand (MD), logistics (LOG), cash flow (CF), and cost pressure (CP), and the policy support that enterprises most desire is the deferral of taxes and fees (DTF).

For the wholesale and retail industry, market demand (MD), labor force (LF), cash flow (CF), and cost pressure (CP) restrict enterprise production and operations. Unlike the cultural tourism industry, wholesale and retail companies with higher cost pressures are more likely to resume production and operations (\( \exp(\beta_{CP}) = 1.738, p = 0.032 \)). The wholesale and retail industry can achieve contactless services by innovating on its distribution methods, while the entertainment, culture, and tourism industries can only provide services in a "face-to-face" or "customer-facing" manner. Therefore, these industries are more susceptible to the impact of policy regulation and are more affected by COVID-19 in the short term. Among these, wholesale and

| variable      | Cultural tourism (N = 174) | Wholesale & retail sales (N = 112) | Information services (N = 164) | Transport logistics (N = 82) |
|---------------|---------------------------|-----------------------------------|-------------------------------|-----------------------------|
|               | Exp(B) | Sig.   | Exp(B) | Sig.   | Exp(B) | Sig.   | Exp(B) | Sig.   |
| Market risk   |         |        |        |        |        |        |        |        |
| MD            | 0.424   | 0.033**| 0.601  | 0.037**| 0.880  | 0.738 | 0.881 | 0.829 |
| CC            | 0.510   | 0.164  | 0.699  | 0.180  | 0.427  | 0.024**| 1.283 | 0.772 |
| Supply chain risk |      |        |        |        |        |        |        |        |
| LOG           | 0.140   | 0.013**| 0.846  | 0.533  | 0.700  | 0.533 | 0.824 | 0.763 |
| SC            | 0.454   | 0.076* | 0.701  | 0.195  | 0.901  | 0.781 | 0.364 | 0.141 |
| Internal risk |         |        |        |        |        |        |        |        |
| LF            | 0.725   | 0.529  | 0.424  | 0.007***| 0.828  | 0.611 | 0.297 | 0.036**|
| CF            | 0.159   | 0.000***| 0.535  | 0.034**| 0.511  | 0.097*| 0.424 | 0.266 |
| PM            | 0.973   | 0.995  | 0.912  | 0.791  | 0.436  | 0.059*| 0.381 | 0.200 |
| CP            | 0.342   | 0.017***| 1.738  | 0.032**| 0.763  | 0.492 | 1.354 | 0.601 |
| External risk |         |        |        |        |        |        |        |        |
| DTF           | 0.370   | 0.025**| 1.026  | 0.920  | 1.204  | 0.626 | 1.107 | 0.865 |
| DL            | 0.828   | 0.676  | 0.772  | 0.319  | 0.376  | 0.009***| 0.572 | 0.379 |
| COF           | 0.919   | 0.848  | 1.600  | 0.134  | 1.061  | 0.895 | 1.481 | 0.572 |
| COT           | 0.896   | 0.805  | 0.572  | 0.062* | 0.722  | 0.394 | 3.146 | 0.051*|
| PPM           | 0.682   | 0.344  | 1.064  | 0.804  | 0.942  | 0.876 | 0.880 | 0.833 |
| SRP           | 1.096   | 0.844  | 3.575  | 0.000***| 1.747  | 0.165 | 4.491 | 0.074*|
| Parallel Line Assumption (Sig.) 0.271 |        |        |        |        |        |        |        |        |
| Goodness of Fit Test (Sig.) 0.000*** |        |        |        |        |        |        |        |        |

Note: ***, **, and * are significant at the 1%, 5%, and 10% levels, respectively.
retail enterprises that have not resumed operations hope that the government has the capacity to coordinate interregional logistics transportation as soon as possible to restore resource mobility ($\exp(\beta_{COR}) = 0.572, p = 0.062$), while enterprises that have reinitiated operations propose simplifying the resumption of the approval process ($\exp(\beta_{SRP}) = 3.575, p < 0.000$).

For the information services and logistics transportation industries, during the period of COVID-19 prevention and control, the market demand (MD) has remained stable and may have even slightly increased. The information services industry is mainly focused on the needs of online education, online offices, online medical diagnoses, etc., and that logistics transportation is primarily focused on the emergency transportation required to move epidemic prevention materials. According to the regression results, the information services industry is susceptible to ($p < 0.05$) customer churn (CC), while the logistics and transportation industry is affected by labor shortages (LF).

The results of the study indicate that multiple factors shape the business continuity. Furthermore, these patterns vary across the industries. The results obtained in this study can be used as the inputs for further integrated models for policy support [46].

6. Conclusions and recommendations

6.1. Conclusions

This study selects 940 service industry enterprises in Hangzhou, China, as a sample to analyze the key factors affecting enterprise production and operations and using ordinal logistic regression and ISM models, and also discusses the logical relationship and hierarchy between the factors. Market demand, logistics, supply chain, labor force, cash flow, reduction in taxes and fees, coordinated transportation, and simplification of the approval process for resuming operations are all significantly related to enterprise operations. With exception of simplifying the approval process for resuming operations, the remaining variables have a negative impact on enterprise operations and sustainable development of business. These results can be used to predict the effects of the government policies in the dynamic environment of the pandemic-related regulations.

Based on the results of the structural interpretation model, we can observe that logistics is a deep-determining factor. Market demand, supply chain, labor force, and cash flow are intermediate-indirect factors. Reducing taxes and fees, coordinated transportation, and simplifying the approval process for resuming operations are surface-direct factors.

The factors that affect enterprise production, operations and sustainable development are heterogeneous across the industries evaluated herein. Compared to the information services and logistics transportation industries, the cultural tourism and wholesale and retail sales are affected by a wider range of factors. In terms of policy requirements, the differences between the industries are extremely obvious. Among them, the cultural tourism industry tends to postpone tax payments, the wholesale and retail industry hopes to simplify the resumption of the approval process, and the information services industry hopes for the realization of policies such as loan discounts. Follow-up surveys are needed to check the effects of adaptation and changes in the behavior of the actors involved on business continuation as the pandemic situation and the related restrictions evolve over time.

6.2. Recommendations

Enterprise production and operations confront many difficulties due to COVID-19. Governments in various countries have formulated policies to help enterprises overcome difficulties and ensure sustainable development. According to the empirical analysis conducted in this research and combined with the Chinese government’s experience in combating COVID-19, we believe that countries should strengthen the following aspects of management on a strategic level.

First, the government should actively promote the establishment of an optimal epidemic management system to improve enterprise ability to prevent and control the pandemic and address other important issues of sustainable development. By relying on Internet technology, governments should closely monitor situations confronted by enterprises following their resumption of production. An employee information reporting system should also be established to provide updates on changes in employee body temperature, activity area, contact population, and other information in a timely manner. Based on the analysis and prediction of the information that is reported, epidemic prevention and control measures should then be adjusted to eliminate the impact of the epidemic as soon as possible and to establish a foundation upon which enterprises can restore a given level of operation.

Second, fiscal and taxation policies should be maximized to support companies in combating the impact of insufficient funds resulting from the epidemic and threatening sustainable development of business. The government should actively adjust its industrial policies, increase its financial support for enterprises, and optimize the existing investment structure. During epidemics, priority must be given to reducing investment or investing redundant funds into epidemic-related fields. Once the epidemic is under control, governmental departments can then increase investment in existing projects and actively promote planned projects to provide strong support for the restoration of economic stability as soon as possible.

Finally, the cultivation of new consumer demand should be accelerated and innovation in business models must be vigorously supported. The government should focus on accelerating the cultivation of contactless business service models and promoting the innovation of business models for e-commerce and unmanned logistics distribution. Enterprises should also adjust their own modes of service as soon as possible, respond quickly to meet the new needs of consumers, and actively promote consumption by this way also addressing other important challenges of sustainable development.

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.

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