The impact of COVID-19 on the management efficiency of enterprise digitization: evidence from 54 countries and regions

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Abstract. Since 2019, the COVID-19 has spread around the world, threatening the stable operation of economies around the world. In a difficult environment, many enterprises are facing digital operational and management challenges. Based on panel data from 2018 to 2021, the empirical results show the following: (1) COVID-19 has a U-shaped effect on the management efficiency of the enterprise digitization. (2) Compared with developing countries, company digitization in developed countries are more affected by COVID-19. (3) More complete digital management technology has a positive, mediating effect on the impact of the management efficiency of enterprise digitization. In light of the findings, in order to cope with the changes in the pandemic, the government, enterprises and individuals need timely attention and support.

Keywords: COVID-19; enterprise digitization; management efficiency.

1. Introduction

In 2019, the world was seriously struck by the outbreak of COVID-19 pandemic. This not only harms enterprise product sales from a supply perspective, but also extremely changes consumers' demand structure, and consequently hampers economic growth. Therefore, enterprises' effective response to the epidemic challenges brought by the epidemic environment has become the important factor to their efficient governance (Fitriasari, 2020).Thus, since 2019, how has the COVID-19 pandemic affected the management and digitization of companies, and how should they be managed efficiently in the post-epidemic era?

Under the adverse effects of the epidemic, organizations are facing new business challenges (Bailey & Breslin, 2021). Although enterprise has long been a topic in corporate research, it remains controversial. Some scholars believe that digital enterprise is a highly interoperable, virtual enterprise infrastructure for individuals, small businesses, and large corporations(Helal et al., 2002). It can also be seen as businesses that provide services on a computer-based basis using a network platform.

The existing papers can broadly be broken down into two different research method, specifically, the qualitative research and the quantitative study. On one hand, Arifah and Melvi (2020) proposed that social media provides a good prospect for increasing the sales of MSME products by surveying 124 samples. This research method is qualitative by using phenomenological predictions. One article uses the synthetic index compilation method to compile industry-wide accounting indexes that capture the period before and after the COVID-19 outbreak (He,et al.2020).

Also, a survey was conducted using the questionnaire method with the Computer Assisted Web Interview technique alongside a self-developed questionnaire. To interpret the obtained data, the descriptive method, principal component analysis, and cluster analysis were used (Sztorc, 2022). On the other hand, some scholars choose qualitative methods to underpin their research. For example, one essay utilizes three distinct types of qualitative data collection methods to gain a better understanding of customers's experience and expectations of internet banking with the purpose to improve their behavior toward internet banking (Naeem, Ozuem, 2021).Hence, it is known from the above papers that most scholars regard the digitization as a medium, and discuss the role of digitization in corporate marketing management under the epidemic. However, direct research on the management changes of digital companies under the epidemic environment is very rare, and it urgently worth to explore this hot topic under post-epidemic era.

This article offers a conceptualization of management efficiency relevant to enterprise digitization. The contributions of this article are as follows. First of all, judging from the existing research, scholars are more concerned about the impact of the epidemic on corporate governance from small, medium and micro enterprises, and there is little research on the direct study of corporate management strategies in the Internet industry under the background of the epidemic. Therefore, this paper draws on relevant indicators and data from other industries to modify and improve and finally research the indicator that is suitable for the management effect of digital companies. The empirical results of the study can also be used to answer the question of how they should be managed efficiently in the post-epidemic era. The research puts forward countermeasures and suggestions for the actual governance in the post-epidemic era, which is in line with the actual needs.

2. Hypothesis

The decline in the company's economic interests has led to a crisis of layoffs and the management system has experienced certain ups and downs. However, this is only a short-lived phenomenon. In the face of the epidemic, company digitization has changed course flexibly, demonstrating the resilience of the economy. For example, enterprise's employees can realize "cloud work" and "cloud meeting" at home only by relying on the computer system. It has spawned a set of "online new economies" with infinite potential.

Given these facts, we propose hypothesis 1:

COVID-19 has a U-shaped effect on the management efficiency of the enterprise digitization.

The Internet has changed the way many companies do business, but has also tended to increase the disparity between firms in developed countries and those in developing countries (Corey & Deitch, 2011). Shafi, Liu, & Renover (2020) proposed that 83% of enterprises in Pakistan were neither prepared nor had any plan to deal with such a situation.Considering these facts, we propose hypothesis 2:

Compared with developing countries, enterprise digitization in developed countries is more affected by COVID-19.

In addition to new capital and new ideas, optimizing enterprise management has an important impact on improving enterprise profitability. Intelligent systems over the cloud have reached a peak where they are considered to be a major key for having a better tomorrow, especially in regards to aspects of the internet sectors (Susanto, Leu & Caesarendra, etc., 2020). Besides, they have drawn on insights from information systems and software engineering research to set a new agenda for studying digitized products as they embed technologies from fast-moving industries (Henfridsson, Mathiassen, & Svahn, 2014). In summary, complete digital management technology can indirectly and positively affect enterprise governance by promoting a convenient work environment that is not hindered by the epidemic.

Therefore, we propose hypothesis 3:

Digital management technology has a positive, mediating effect on the impact of COVID-19 on enterprise digitization.

3. Methodology

3.1 Data

The present research used secondary data from the IMD World Digital Competitive Ranking, GDP as well as population numbers from World Bank Indicators, the efficiency Index from Global Connecting index (GCI), the Household consumption index from UN data, and other sources. The data were for the 2018–2021 period. Our collected sample is at the country level, which includes 54 countries and regions globally.

3.2 Variables

The main dependent variable in this paper is management efficiency, which indicates the global ranking. The source of management efficiency is the IMD alumni community and their panel of experts from all over the world. The efficiency index of this paper is produced by the ratio of the Knowledge and Future Readiness.The specific calculation of the management efficiency index report indicators is in Table 1.

Table 1. Data sources for management efficiency

Category	Index	Data source	Coverage
Knowledge	Talent Training and education Scientific concentration	The IMD Alumni community	2019 - 2021 54 countries
Future Readiness	Adaptive attitudes Business agility IT integration	the IMD Alumni community	

Source: https://www.huawei.com/minisite/gci/cn/methodology.html

Based on the data and indicators recognized both in academia and in practice, this paper attempts to measure whether the density of COVID-19 cases in various countries exerted a negative effect to country's management efficiency. As a measure of COVID-19 in distinct countries, X is the ratio of the total number of confirmed COVID-19 cases divided by total population and total area of each countries and regions. The larger the ratio is, the more serious the epidemic is in the country and the greater the impact on social production.

Moreover, only by controlling all the variables that can cause the change of dependent variables except independent variables, can we make clear the causal relationship in the experiment. We selected four control variables, namely GDP, resident consumption index, number of secure Internet servers, population and land area. They all affect management efficiency from a relatively macro level.

When it comes to hypothesis 3, the cloud rate and cloud service investment in each country will affect the management efficiency of enterprises.The methodology for measuring these two indicators comes from the GCI, which draws on authoritative industry data, including the Organization for Economic Cooperation and Development OECD, ITU, GSMA, world economy Forum (WEF), World Bank, UN, Ookla, IDC, Huawei.Its calculation method is based on the realization of the target value, the original data for standardized conversion, the score of each country's indicators. Generally, if the actual value is less than 10% of the target value, the indicator score is 1; If the actual value is between 11% and 20% of the target value, the indicator score is 2 points, and so on.

3.3 Model

Due to the panel date of this paper, we use the panel fixed effect to measure the model. Hence, the main basic empirical equation is a panel fixed effect model:

$$Efficiency_{it} = \alpha + \alpha coviddensity + \alpha coviddensity^2 + \alpha cloudcovid + \alpha GDP_{it} + \alpha population_{it} + \alpha CPI_{it} + \alpha safeinternet_{it} + \alpha area + \beta X_{it} + v_i + u_{it} \quad (1)$$

Where i and t represent country and time respectively; Efficiency indicates efficiency of enterprise management; coviddensity means the ratio of the total number of confirmed COVID-19 cases divided by total population and total area of each countries and region; coviddensity^{2}means the square of coviddensity. Coludcovid represents the cross between the information management system and the number of confirmed COVID-19 cases; GDP represents gross domestic product in distinct countries; CPI shows consumer price index; Population is the number of people in each country; Safe Internet

is the number of secure servers per million people in different countries; Area is the land in different countries; X are the control variables; vi is the individual effect and vt is the residual.

4. Empirical Analysis

4.1 Fixed effect model analysis

table 2. as below shows the fixed effect of the coviddensity on efficiency

	(1) Efficiency	(2) Efficiency
Coviddensity	-0.012***	-0.009***
	(-4.295)	(-4.295)
$Coviddensity^2$		-0.026***
		(-5.121)
Control	Yes	Yes
_cons	1.082***	0.751***
	(5.642)	(4.123)
N	108	108
R^2	0.002	0.011
r2_a	-1.054	0.017
F	0.044	0.078

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 1 shows that coefficient of coviddensity in model (1) is significant at the 1% level, and the absolute value is 0.012. It implies that to some extent, the seriousness of COVID-19 may have positive relations with management efficiency of enterprise digitization (Efficiency is a negative index, which means the lower the index value, the higher the management efficiency is).

Furthermore, we add the square of covidedensity in the model (2), the empirical result shows the coefficient of Coviddensity2 is significant at 1% level and its value is negative. As the dependent variable Efficiency is a negative index, it means there is an U-shaped relations between coviddensity and efficiency. Hence, it indicates that our hypothesis 1 is be proved. There is an U-shaped correlation between the density of COVID-19 cases in different countries and the management efficiency of companies in that country.

4.2 Regional heterogeneity test

For regional heterogeneity test, we divided the countries into two groups, developed countries (26 countries; see the appendix) and developing countries (28 countries; see the appendix).

table 3. as below shows the fixed effect of the coviddensity on efficiency in distinct countries

	(3) Developing Efficiency	(4) Developed Efficiency
Coviddensity	-0.005***	-0.034***
	(-3.005)	(-5.496)
Control	Yes	Yes
_cons	1.184**	-0.601
	(2.673)	(-0.252)
N	56	52
R^2	0.000	0.026
r2_a	-1.115	-1.069
F	0.000	0.326

Based on the observation of the average effect of samples, we believe that the impact of COVID-19 cases on enterprise management efficiency may vary depending on the geographical location of countries. To test this difference, referring to previous studies, we divided 54 countries into developed countries and developing countries for heterogeneity test. The results show that the efficiency coefficient based on model (3) is positive at 1% significance level, indicating that regional location significantly affects enterprise management efficiency. Similarly, the coefficient of efficiency variables based on Model (4) is also positive at the 1% significance level, indicating their correlation. By comparison, developed countries have the largest impact on enterprise management efficiency, while developing countries have a smaller impact on enterprise management efficiency. Hypothesis 2 is established.

4.3 Mechanism

The next challenge is identifying the path through which coviddensity affect the enterprise management efficiency. In the theoretical analysis, this paper argues that the regional differences may have a substantial impact on management efficiency of enterprise digitization in different countries through distinct mechanisms. In the model design, we put the mediation variables in the benchmark model to investigate whether the influence mechanism is significant. The specific model design is as follows:

$$Efficiency_{it}=\theta_1\ (cloud_{it} \times coviddensity_{it}) + \theta_2 coviddensity_{it} + \theta_3 cloud_{it} + \beta x_{it} + v_i + u_{it} \quad (2)$$

The meaning of these variables are defined as in formula (1). We think that complete digital management technology can influence enterprises through two channels: cloud rate (cloud) and cloud service investment (cloud2).

In the era of big data, a complete information technology management system is the cornerstone of enterprise management. In this paper, it is reflected from the cloud rate and cloud service investment indicators. Cloud rate is used to assess the demand for advanced public cloud services in relation to total ICT expenditure and cloud2 is the proportion of total IT expenditure of a country's cloud service provider.

Table 4. as below shows the fixed effect of the cloud on efficiency

	(1) Efficiency	(2) Efficiency
cloud	−0.019*** (−4.755)	
cloud2		−0.018*** (−4.264)
Control	Yes	Yes
_cons	0.508 (1.203)	0.523 (1.247)
N	162	162
R^2	0.679	0.682
r2_a	0.498	0.503
F	43.537	44.173

It is found that the coefficient of cloud and cloud2 is still significantly positive at the 1% level, and the absolute value is 0.019 and 0.018 respectively. Both cloud rate and cloud service indicators can reflect the level of technology. The meaning of cloudcovid means the intersection of coviddensity and cloud.

Table 5. as below shows the fixed effect of the cloudcovid and coviddensity on efficiency

	(5) Efficiency	(6) Efficiency
Cloud covid	0.011***	
	(3.507)	
cloudcovid2		0.013***
		(3.489)
Covid density	−0.009***	−0.008***
	(−4.011)	(−3.981)
Control	Yes	Yes
_cons	1.026***	1.028***
	(17.911)	(18.114)
N	54	54
R^2	0.700	0.700
r2_a	0.661	0.661
F	18.249	18.239

Table 5 shows that the mediation effect coefficients of technology management system. When it is used as a mediation index, the effect is positive which proves Hypothesis 3. The coefficients of cloudcovid and cloudcovid2 are significant positive at 1% level in model (5) and (6), which means the mediation effect of cloud and cloud2 on the impact of coviddensity on efficiency is positive.

5. Conclusion and discussion

5.1 Research conclusions and theoretical contributions

Based on panel data from 2018 to 2021 from 54 countries, this paper examines the relationship between COVID-19 and management efficiency of enterprise digitization using a fixed effect model. The study found that the severity of COVID-19 has a significant U-shaped impact on the management efficiency of companies. On the whole, this paper proves that information technology empowerment helps to create an efficient, convenient and rapid management environment. Meanwhile, the regional heterogeneity of them is tested. After dividing the samples into developed and developing countries, we found that the COVID-19 cases had a certain negative impact on enterprise management in all countries in the early stage of the epidemic. However, this impact was short-lived and gradually improved with the rapid response and technical support of the information technology market. Comparatively speaking, under the impact of COVID-19, the management efficiency of enterprises in developed countries is more affected, which may be because the GDP, CPI and other indicators of developed countries are quite different from some developing countries, and the number of enterprises and workers in developed countries is often more than that in developing countries. This makes the damage to developed countries even more severe as the pandemic slows down mobility and productivity. The research results confirm that developing countries have obvious advantages in the optimization of enterprise management efficiency in the kinds of industry, which needs to be further promoted to promote its development.

It has only been three years since the outbreak of COVID-19, and there is still insufficient quantitative research on the impact of COVID-19 on enterprise management. This paper has some contributions to enrich research results on enterprise management under the COVID-19 pandemic. First, this study empirically tested the impact of the epidemic on enterprise management efficiency in different countries through national-level panel data, providing more solid empirical evidence for optimizing the environment for enterprise management efficiency. Secondly, this paper tests the regional heterogeneity of enterprise management efficiency in the Internet industry. Although existing studies have reached a consensus on the significant regional differences in this topic, there is a lack of discussion on how different types of countries produce differentiated effects on management efficiency. This paper introduces the mediation variable, which proves that the variable can affect the level of enterprise management efficiency.

5.2 Policy implications

The research conclusion of this paper has three policy implications for further improving the management efficiency of enterprise digitization.

First of all, as the saying goes, the process of development is tortuous, but the future is bright. In the normal stage of the epidemic, the management efficiency of the enterprise digitization is bound to undergo greater changes in the future to cope with various uncertainties under the epidemic. What is more, the enterprise management efficiency is likely to maintain a good development trend. In order to cope with the changes in the epidemic, generally speaking, the government, enterprises and individuals need to pay timely attention to, support and help (Fitriasari, 2020).

Second, hypothesis 2 gives us a clue. In the study of enterprise management efficiency in different types of countries, developed countries are more traumatized than developing countries, which requires attention to the following two main aspects of enterprise management efficiency governance in developed countries.

First, at the national level, a more complete emergency management information system is needed to facilitate the smooth operation of the social economy and the resumption of work and production of enterprises during the epidemic.

Moreover, in recent years, network attacks on website systems by taking advantage of the epidemic have increased significantly. Therefore, network security work should be carried out in a timely manner to monitor and analyze hacker attacks. Second, at the enterprise level, enterprises should make efforts to build a diversified online technology management platform, especially to build a comprehensive management platform, strengthen the scientific, effective and comprehensive application of network technology and even intelligent technology.

In this way, all kinds of network platforms and data management can be concentrated, so as to provide support and guarantee for management decisions and promote the improvement of management efficiency. In terms of enterprise management efficiency governance in developing countries, the number, scale and development stage of enterprises themselves may be relatively backward and weak, resulting in small fluctuations. Therefore, developing countries should start from improving the development level of their own enterprises. Enterprises should enhance their independent research and development capabilities, develop the big data processing technology they need.At the national level, it is necessary to improve its own infrastructure level and establish a good national network system.

Furthermore, information technology management tools as a regulatory tool will have a certain impact on the efficiency of enterprise management. Therefore, give us the following enlightenment: based on the analysis of the content and form of enterprise information management, the application of computer network technology can play an auxiliary role in effectively managing the large amount of information formed in the operation and construction of enterprises.

5.3 Research limitations and prospects

The limitations of this paper mainly lie in three aspects. First, it is the insufficient collection of panel data volume. Since the outbreak of COVID-19 has only been a few years, the indicators of COVID-19 epidemic in some developing countries are not perfect yet, which makes it necessary to exclude these data in this study. In addition, it is the beginning of the year 2022, and the data of 2021 in some aspects have not been updated in time, resulting in the loss of some data. Further data can be collected in future studies over time to verify the accuracy of this model.

Secondly, the mediating variable "information management technology level" is introduced in this paper to preliminary test whether COVID-19 affects the management efficiency of enterprise digitization through this variable, but more detailed and in-depth causal mechanism and more abundant mediating variable indicators need to be further explored.

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