EFFECTS OF ECONOMIC SHOCKS ON HUMAN BEHAVIOR, MENTAL LIFE AND THE ENVIRONMENT: IMPLICATIONS FOR THE POST- COVID-19 CRISIS ERA

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Editorial: Effects of economic shocks on human behavior, mental life and the environment: Implications for the post-COVID-19 crisis era

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Editorial on the Research Topic
Editorial: Effects of Economic Shocks on Human Behavior, Mental Life and the Environment: Implications for the Post-COVID-19 Crisis Era

The COVID-19 pandemic has imparted fundamental economic shocks to society. Indeed, the COVID-19 pandemic is a threat to individual health and survival. Its onset changes human behavior in both the short- and long run. This issue may lead to changes in human behavior and affect mental life. The lifestyle change during the COVID-19 pandemic has also increased depression and suicide. The COVID-19 pandemic requires an integrated effort from governments, institutions, organizations, and communities to combat this health crisis.

The "CoVesity" issue conflated the rise in obesity with the various measures (e.g., lockdowns, curfews, social distancing), which significantly reduced human activity, mobility, and hence exercise (Zakka et al., 2021; Ertz and Le Bouhart, 2022). In addition, some studies attempted to further detail how it might be possible to take advantage of the pandemic to reach a more sustainable society. In the following, a consortium of researchers used several theoretical frameworks to suggest a triple-layered (systemic) shift toward more sustainable societies: (1) proactive politics funded over time (decision-makers); (2) agile and socially responsible organizations; (3) agentic and empowered citizens (consumers) (Trespeuch et al., 2021).

The nature of businesses everywhere is also transforming in the aftermath of this global pandemic; for example, online working from home is increasingly adopted by companies wishing to reduce fixed costs and minimize organizational risk. There will also be significant changes in networking and social interactions. These issues affect the workers' emotions, mental fatigue, and stress. In addition, on a societal level, people's attitudes toward one another may be transformed, as exemplified by voluntary groups' growth to support vulnerable community members. For instance, good neighborliness and altruism exert pressure for change in government and businesses, especially in free-market economies, where economic considerations

are now beginning to dominate the debate. Given these backdrops, this research topic contains 18 papers on the effects of economic shocks on human behavior, businesses and financial markets.

Regarding papers focusing on individuals' behavior, Rojas-Méndez uses the data for more than 24,000 individuals living in 30 different countries and finds that socio-economic variables and cultural dimensions are essential in explaining people's concerns about the adverse effects of the COVID-19 pandemic. Song et al. show that China's New Rural Cooperative Medical System increases the Chinese people's happiness by promoting poverty alleviation and rural revitalisation. The system will help combat the adverse outcomes of the COVID-19 pandemic. Lu and Lin discuss the economic and social consequences of the COVID-19 pandemic and offer a conceptual analysis of how the COVID-19 pandemic affects individual mental health and coping behaviors from the perspectives of personal social contexts. In addition, Ai et al. find that physical exercise decreases people's anxiety, sadness, and depression during the COVID-19 pandemic. Gong et al. review the effects of the declining global gross domestic product due to the outbreak of the COVID-19 pandemic on mental problems. Xie et al. obtain valuable evidence for policymakers fighting against the COVID-19 pandemic and find that the self-construction methods explain wellbeing with the different consumption choices.

Several papers have focused on the business aspect of the COVID-19 pandemic. Liu et al. discuss that cross-culture conflict management is an essential issue for Chinese firms during the COVID-19 pandemic. Wu and Zhu suggest that Chinese firms' Corporate Social Responsibility engagement policies fight against the negative consequences of the COVID-19 pandemic. Ma et al. review the effects of the COVID-19 pandemic on global inequality and find the persistency in inequality among countries' service sectors. Ma et al. also show that the service sector is the most significant contributor to global inequality, which may be substantial evidence for the post-COVID-19 era. According to Ma et al., there has been a considerable decline in global inequality from 2000 to 2017, and East Asian economies have contributed almost 40% of this decline in global inequality. Hu et al. indicate that the lockdown during the COVID-19 pandemic led to a short-run reduction in carbon dioxide emissions in 30 Chinese regions in 2020. Wang implements 210 valid questionnaires for employees in different Chinese enterprises and shows that the dynamic work environment positively affects innovative performance during the COVID-19 pandemic. Chen et al. discuss the effects of the big data capability on financial performance in Chinese firms in the context of the digital economy explosion during the COVID-19 pandemic.

Several papers have also analyzed the effects of the COVID-19 pandemic on financial markets. For instance, Jiang et al. observe that investors' sentiment in China (measured by the Baidu index) is crucial for predicting stock trends in China. The evidence may be helpful for the COVID-19 pandemic. Song et al. also show that investor sentiment is an essential determinant of the stock market returns of the newly listed Chinese companies from October 2019 to June 2020. Sun et al. obtain the negative impact of the COVID-induced public anxiety, measured by Google Trends and Wikipedia data, on 14 European stock markets from January 2, 2020, to September 17, 2020. Lu et al. find that the COVID-19 pandemic caused a significant increase in the risk perceptions for the stock market performance of the United States airline companies.

In short, this research topic covers 18 papers on the consequences of the COVID-19 pandemic with its effects on individuals, businesses, and financial markets (especially the stock market returns).

Author contributions

GG writing and reviewing the manuscript. CL and JM writing the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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BRIEF RESEARCH REPORT
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Efficiency Analysis of New Rural Cooperative Medical System in China: Implications for the COVID-19 Era

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The sudden outbreak of coronavirus disease 2019 (COVID-19) has caused a huge impact on the Chinese residents' health and economic level. In the pandemic background, the country and its institutions have introduced pandemic-related insurance to stabilize the national situation. At this stage, insurance has played an increasingly important role in social life. With the popularization of insurance, the idea of buying insurance to avoid risk has gradually become popular among people. Among them, the New Rural Cooperative Medical System (NRCMS) has been farmers' common choice. The NRCMS, a mutual aid system created by farmers spontaneously in the country, plays a great role in guaranteeing farmers access to basic health services, alleviating poverty caused by disease and returning to poverty due to disease, and promoting poverty alleviation and rural revitalization. Given this backdrop, we study the efficiency of the NRCMS that can effectively promote poverty alleviation and rural revitalization and ensure the people's happy life. Implementing the Data Envelopment Analysis (DEA), we find that technological progress is one of the main factors influencing the efficiency of the NRCMS. Therefore, it is important to improve the technology for providing the efficiency of the NRCMS and promoting the happiness of the society.

Keywords: two-stage network idea, DEA-Malmquist, New Rural Cooperative Medical System, COVID-19 pandemic, efficiency

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) continues to appear in many countries, which has brought many bad effects to the country and society. As of March 31, 2021, the number of infected people globally is almost 130 million, and the number of cases is increasing by more than 600,000 every day. The spread of infection affects all countries and regions worldwide and has caused more than 2.8 million deaths worldwide (Dong et al., 2020). This outbreak has infected a large number of people. The pandemic, which has infected so many people and spread so fast, is the most serious infectious disease disaster human society has experienced in nearly 100 years. Now, the global COVID-19 pandemic has not been effectively contained, and many European countries are beginning to experience a third-wave of the pandemic. However, if the global scientific and medical fields spare no effort to combat the pandemic, the future of the pandemic is uncertain. However, governments' policy and trust in these policies are central to combat the pandemic (Gozgor, 2021).

At this stage, we need to deeply analyze the impact of COVID-19 on the country and society, improve the long-term mechanism for global public security, improve the global governance system, and accelerate a community building with a shared future humankind. Under the pandemic situation, the New Rural Cooperative Medical System (NRCMS) has also played a certain role. The NRCMS was formally proposed by the Chinese government in October 2002 to actively guide farmers to establish a new type of rural cooperative medical insurance based on overall planning for serious diseases. In 2009, the NRCMS was established for the status of the rural basic medical security system. Until now, the NRCMS in the country has experienced a leap-forward development, reduced a lot of burden to farmers, and at the same time given a certain security. Many scholars study the effect of new farming in succession, and the corresponding research is as follows below.

For instance, Zhao and Gan (2019) proposed that the NRCMS improves the rate of rural residents receiving medical treatment, plays a significant role in reducing residents' medical expenditure, alleviates the acceptance pressure of municipal hospitals, guides rural residents to seek medical treatment nearby, and improves the utilization rate of medical services. Wang et al. (2009) proposed that participating in the NRCMS can effectively improve rural residents' medical services. Guo (2020) showed that under different risk preferences, farmers' participation in the NRCMS would also change and analyzed the influence of subjective and objective risk preferences on their insurance behavior. Guo et al. (2013) used the gray correlation analysis method to get the gray correlation order of the influencing factors of the NRCMS. The NRCMS should be designed and improved to adapt to objective conditions to achieve sustainable development. Cui et al. (2021) studied the province's livability level measurement based on the two-stage Data Envelopment Analysis (DEA) model. The authors comprehensively evaluated the livability level of the province from seven aspects. Xiao and Yang (2020) evaluated listed companies' innovation efficiency in China's wine industry based on a two-stage network DEA. They concluded that there were great differences in the innovation efficiency among listed companies in China's wine industry. There was an imbalance in the input and output of the technology development stage in innovation activities. Wang (2020) concluded that the new energy industry's overall financing efficiency was relatively low by constructing a two-stage chain network DEA model. Chen and Guan (2021) concluded that the allocation efficiency of health resources in traditional Chinese medicine (TCM) hospitals in China was poor using the DEA–Malmquist index. Jin et al. (2021) carried out static and dynamic analyses on the efficiency of inclusive digital finance regulating urban and rural residents' welfare differential in 31 provinces of China based on the DEA–Malmquist–Tobit model. The authors provided the main factors affecting inclusive digital finance's efficiency regulating urban and rural residents' welfare differential. Yang et al. (2021) studied county-level public hospitals' operational efficiency in Hainan Province based on the DEA–Malmquist model. The authors proposed the need to raise the technical efficiency and the scale efficiency.

In conclusion, the NRCMS has played an important role in recent years. Further exploration of the efficiency of the NRCMS can help better implement the NRCMS policies. In this paper, the two-stage network DEA and the DEA–Malmquist are used to study the efficiency of the NRCMS. There are few research studies on the NRCMS by this method in China, which helps explore the key influencing stages of the NRCMS to determine the important influencing factors. We enhance the previous papers by using new methods and provide some implications on the COVID-19 era.

The rest of the paper is organized as follows. The Methodology section explains the methodologies used in the paper. The Empirical Analysis section provides the details of the empirical analyses. The Conclusion section concludes.

METHODOLOGY

Two-Stage Network DEA

The specific model of the two-stage network DEA is constructed as follows: suppose there are many influencing factors, and each influencing factor has *n* inputs, *m* outputs, and *g* intermediate outputs, where Xi is the input of the first-stage fundraising system of the i-th influencing factor (DMU), $Xi = (xi1, xi2..., xin)^T$; Yi is the output of the first-stage fundraising system and the input of the second-stage fund allocation system of the i-th decision unit, $Yi = (Yi1, Yi2...Yig)^T$; Zi is the output of the fund allocation system in the second stage, ZI = (ZI1, ZI2... ZIN); and O = (O1, O2..., ON), P = (P1, WP2..., pg), Q = (q1, q2..., qm), respectively, represent the weights of input, intermediate, and output variables.

$$\begin{cases} OTx_0 = 1 \\ QTYi - O^TXi \le 0 \\ \text{s. t. } PTYi - O^TXi \le 0 \\ QTZi - P^TYi \le 0 \\ Q \ge \varepsilon em, O \ge \varepsilon ep, P \ge \varepsilon eg \end{cases} \quad (1)$$

Where ε is a non-Archimedes infinitesimal quantity, e T = (1, 1...1). If O*, P*, and Q* are the optimal solution of the model, then the efficiency of DMU whole process and sub-process is $E_0 = Q^{*T}Z_0\ O^{*T}X_0$, $E1 = Q^{*T}Z_0/O^{*T}Y_0$, $E2 = Q^{*T}Z_0/O^{*T}Y_0$, where E_0 is the whole stage, E1 and E2 are the first and second stages, respectively, and $E_0 = E1 \times E2$.

DEA–Malmquist Method

Fare et al. (1994) combined a nonlinear programming method of the Malmquist index theory with the DEA method theory, making the Malmquist index widely applied in the empirical literature. This method has been widely applied to measure production efficiency in finance, industry, medical treatment, and other sectors, and international comparative studies have been conducted based on efficiency measurement results. The specific formula is as follows:

suppose (xt,yt) represents the input and output of the t period, (xt + 1,yt + 1) represents the input and output of the t + 1 period, and $D_0(xt + 1,yt + 1)/D_0(xt,yt)$ represents the change

of technical efficiency from t period to t + 1 period under the technical conditions of the t period; $D_0T + 1(X\ T + 1, Y\ T + 1)/D_0T + 1(X\ T, Y\ T)]^{1/2}$ represents the change in technical efficiency from T to T + 1 under the technical conditions of T + 1, where the subscript 0 represents the constant return to scale. The following formula can express the Malmquist index:

$$M_0\left(x^t, y^t, x^{t+1}, y^{t+1}\right) = \left[D_0\left(x^{t+1}, y^{t+1}\right)/D_0(x^t, y^t) \times D_0^{t+1}\left(x^{t+1}, y^{t+1}\right)/D_0{}^{t+1}\left(x^t, y^t\right)\right]^{1/2} \quad (2)$$

At the same time, the Malmquist approach can be divided into two parts: technical efficiency and change. The specific formula is as follows:

$$\text{Technical efficiency EC} = D_0T + 1\,(X_0T + 1, Y_0T + 1)/D_0\,(X_0T, Y_0T) \quad (3a)$$

$$\text{Technical change Tc} = \left[D_0t(x_0t + 1, y_0t + 1)/D_0\left(x_0t + 1, y_0t + 1\right) \times D_0t + 1\left(x_0t + 1, y_0t + 1\right)/D_0t + 1\left(x_0t, y_0t\right)\right] \quad (3b)$$

$$M = EC * TC \quad (3c)$$

EC mainly refers to the utilization of existing technology by decision-making units if EC > 1 means that the efficiency of the main body of production is improved, resources are fully utilized, and management level is improved. On the contrary, if EC < 1, resources are not fully utilized, main body efficiency is poor, and management level needs to be strengthened. TC mainly reflects the technological progress on the decision-making unit if Tc > 1 indicates technological progress. Tc < 1 indicates no technological progress or regression, and continuous improvement of the technology is needed. Tc = 1 indicates no technological progress.

EMPIRICAL ANALYSIS

Sample Description

In this paper, the data are selected from the year between 2004 and 2014, the ×1 [the new rural cooperative medical county (area and city)], ×2 (to participate in the new rural cooperative medical number), ×3 (the new rural cooperative medical service rate), ×4 (the new rural cooperative medical fund spending), ×5 (the total amount of the new rural cooperative medical financing this year), and ×6 (the new rural cooperative medical compensation benefit passengers). The data are obtained from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) of Zeng et al. (2017). The descriptive statistics of raw dataset is reported in **Table 1**.

Results of the Two-Stage Network DEA Method

The results of the two-stage network DEA method are provided in **Table 3**.

It can be seen from **Table 3** that the overall efficiency of the second stage is higher than that of the first stage; there are 3 years with an efficiency value of 1 in the second stage, and only one year with an efficiency value of 1 in the first stage; the efficiency value of the second stage from 2009 to 2014 is generally high. Therefore, the first stage mainly affects the overall efficiency; in the year 2005, 2006, 2008, and other years, the efficiency of the first stage is poor, but the efficiency of the second stage is efficient, indicating that there may be technological progress in the second stage compared with the first stage.

Results of the DEA–Malmquist Method

The results of the DEA–Malmquist method are provided in **Table 4**.

As shown in **Table 4**, every year, the EC, PEC, and SEC's efficiency values are obtained as one. This evidence indicates an efficient situation. In addition, the efficiency value of the TC was not up to 1 every year. This case is a situation where there is no progress or deterioration in the technology. Still, with the

TABLE 1 | Descriptive statistics of raw dataset.

Time	X1 (PCS)	X2 (million people)	X3 (%)	X4 (million yuan)	X5 (million yuan)	X6 (million people)
2014	2,349	7.36	98.9	2,890.4	3,025.28	16.52
2013	2,489	8.02	99	2,908	2,972.48	19.42
2012	2,566	8.05	98.3	2,408	2,484.7	17.45
2011	2,637	8.32	97.5	1,710.19	2,047.56	13.15
2010	2,678	8.36	96	1,187.8	1,308.33	10.87
2009	2,716	8.33	94.2	922.9	944.4	7.59
2008	2,729	8.15	91.5	662.3	784.58	5.85
2007	2,451	7.26	86.2	346.63	427.97	4.53
2006	1,451	4.1	80.7	155.8	213.59	2.72
2005	678	1.79	75.7	61.75	75.35	1.22
2004	333	0.8	75.2	26.37	40.29	0.76

*The input/output/intermediate variables of the two-stage network DEA are provided in **Table 2**. The input/output variables of DEA–Malmquist are also reported in **Table 2**.*

TABLE 2 | Variables in the two-stage network DEA.

Input/output	Names of index	Index tag	Units
Input	Counties (districts and county-level cities) carrying out the new rural cooperative medical care system	X1	Pcs
	Number of people participating in the new rural cooperative medical care system	X2	Million people
	Expenditures for the new rural cooperative medical care system	X4	Million yuan
	New rural cooperative medical system this year total financing	X5	Million yuan
Intermediate	Participation rate of the new rural cooperative medical care system	X3	%
Output	The number of beneficiaries of the new rural cooperative medical care system	X6	Million people
Variables in the DEA–Malmquist Method			
Input	Counties (districts and county-level cities) carrying out the new rural cooperative medical care system	X1	Pcs
	Number of people participating in the new rural cooperative medical care system	X2	Million people
	Expenditures for the new rural cooperative medical care system	X4	Million yuan
	New rural cooperative medical system this year total financing	X5	Million yuan
Output	Participation rate of the new rural cooperative medical care system	X3	%
	The number of beneficiaries of the new rural cooperative medical care system	X6	Million people

increase of time, the efficiency value of the TC closer to 1 shows that the technology is improving year by year, but the efficiency value is no more than 1. Therefore, the most important reason why the *M*-value is <1 is that the TC value is <1. In terms of the ranking of the *M*-value, the top 5 years were 2010–2014, among which 2011 ranked first and 2010 ranked as the fifth.

CONCLUSION

Our empirical analyses in this paper show that the first stage's efficiency is poor, the second stage's efficiency is efficient, and the overall efficiency is poor. Therefore, the first stage is the stage that mainly affects the overall efficiency. We suggest that the second stage is more efficient than the first stage for the following reasons. In 2009, the new agricultural cooperation was established as the basic medical security in rural areas. Then, from 2010 to 2014, relevant documents and policies were issued every year. For example, in 2010, the Eleventh Five-Year Plan Conference was held, requiring the NRCMS to cover more than 80% of rural areas by 2010. In 2011, the medical and health system's five key reforms were promulgated, which raised the standard of medical insurance subsidy from 120 to 200 RMB per person. Since then, the cost of medical insurance subsidies has been increasing continuously every year. In 2014, the Notice on Raising the 2014 Funding Standards for the New Rural Cooperative Medical Care and the Basic Medical Insurance for Urban Residents was issued. The subsidy for medical insurance was raised to 320 RMB per person, increasing 40 RMB than the subsidy in 2013. These subsidies are significantly increasing in the COVID-19 era, and it enhances the happiness and life satisfaction of the Chinese farmers. However, China's medical insurance funding level, especially basic medical insurance for rural and non-working urban residents, is still low. For example, vaccines are not included in the medical insurance coverage, and public health funds paid vaccinations.

TABLE 3 | Results of the two-stage network DEA method.

No	Node	DMU	Score	Ranking
1	1	2004	1	1
2	1	2005	0.494416	13
3	1	2006	0.246282	20
4	1	2007	0.242821	21
5	1	2008	0.281633	17
6	1	2009	0.235476	22
7	1	2010	0.342022	15
8	1	2011	0.371864	14
9	1	2012	0.265954	19
10	1	2013	0.305135	16
11	1	2014	0.27504	18
12	2	2004	1	1
13	2	2005	1	1
14	2	2006	1	1
15	2	2007	0.831183	6
16	2	2008	0.585505	12
17	2	2009	0.759278	9
18	2	2010	0.784924	8
19	2	2011	0.642427	11
20	2	2012	0.845297	5
21	2	2013	0.786354	7
22	2	2014	0.657252	10

To sum up, due to the implementation of relevant policies and each subsidy fee adjustment that is more in line with the national conditions, the NRCMS gradually develops well. In 2008, the overall efficiency and the first-stage efficiency were poor, but the second stage efficiency is better. This evidence means that the second stage is a technological improvement over the first stage. Technological progress is the main reason that affects the

TABLE 4 | Results of the DEA–Malmquist method.

Time	Stage	EC	TC	PEC	SEC	Number of M	Ranking
2005	A	1	0.607443	1	1	0.607443	9
2006	A	1	0.62593	1	1	0.62593	8
2007	A	1	0.688009	1	1	0.688009	7
2008	A	1	0.802715	1	1	0.802715	6
2009	A	1	0.981397	1	1	0.981397	2
2010	B	1	0.892905	1	1	0.892905	5
2011	B	1	0.990985	1	1	0.990985	1
2012	B	1	0.97817	1	1	0.978171	3
2013	B	1	0.953863	1	1	0.953863	4

M-value, which is related to some less mature technologies of the NRCMS.

There are several implications, especially for the COVID-19 era. First, the procedures for participating in and applying for reimbursement for the NRCMS are tedious, and farmers are worried that the policy will change every year and not get adequate protection. Second, unable to cross area to hand in, new agriculture closes to want to attend domicile ground, cannot be in residence place to hand in, and protect personnel from ginning to bring certain not convenient. Third, it is inconvenient to reimburse other places, and the payment channel is single. It can only be reimbursed in the place of residence, and the round-trip fare is not necessarily cost-effective. Fourth, with the growth of years, technology keeps developing, but the efficiency value has not exceeded. Therefore, technology needs to be further improved, such as developing corresponding software to simplify the cumbersome insurance reimbursement procedures. In this software, one can see the payment cost and time of different places. One can also make payment and settlement in the corresponding software to get the corresponding guarantee regardless of where you live or in other places. In this way, the NRCMS will develop better and better and better guarantee farmers out of poverty and promote rural revitalization. The outbreak of the pandemic has also aroused people's deep thinking about rural medical treatment. The pandemic prevention and control in rural areas face great challenges because of the relatively weak medical and health conditions, the large number of people going out and returning home, and the large mobility. It is necessary to implement relevant policies of the NRCMS by combining the pandemic situation so that farmers can have insurance to rely on, and the NRCMS can play an important role during the pandemic period to strengthen the prevention and control in rural areas.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: The data are obtained from the Chinese Longitudinal Healthy Longevity Survey (CLHLS) of Zeng et al. (2017): https://www.icpsr.umich.edu/web/ICPSR/studies/36692.

AUTHOR CONTRIBUTIONS

KS: implementing empirical analyses. W-BL: writing the manuscript. YQ: data collection and methodology. M-NT: reviewing the manuscript. W-TP: funding access. All authors contributed to the article and approved the submitted version.

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BRIEF RESEARCH REPORT
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Integration of the Confucian Culture on Cross-Cultural Conflict Management: The Role of the COVID-19 Pandemic

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Cross-culture conflict management is the major challenge for the Chinese enterprises going global along the Belt and Road Initiative. This study explores the feasibility of integrating the Confucian culture into cross-culture conflict management, and a special role is given to the COVID-19 pandemic. We combine the Confucian culture values and Hofstede's cultural dimension theory and adopt the questionnaire survey methods on the Chinese multinational enterprises' employees. The Cronbach's Alpha method is also deployed to test the reliability and validity of the data. We find the significant integration of the Confucian culture into cross-culture conflict management. Furthermore, 16 sub-values of the Confucian culture are suggested to mitigate the cross-culture conflicts in multinational enterprises effectively. The findings imply that Chinese enterprises should consider new strategies to manage the cross-culture conflicts, especially during the COVID-19 pandemic.

Keywords: the Belt and Road initiative, COVID-19 pandemic, confucian culture, cross-cultural conflict management, integration

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INTRODUCTION

"The Belt and Road Initiative" (hereinafter "BRI"), abbreviated from the twenty-first century Maritime Silk Road and Silk Road Economic Zone, is an initiative proposed by President Xi Jinping and was initially implemented in 2013, aiming to establish a new model of international relations featuring Win-Win cooperation and forge a community of shared future of humankind. "BRI" advocates a peaceful and amicable international environment and enhances economic development with cooperation with the rest of the world. As for business cooperation with companies worldwide, China seeks harmony without uniformity and fosters amity with the neighboring countries. "BRI" shows China's commitment to mutual benefits with the countries and the pursuit of economic prosperity all over the world.

With the progression of "BRI," Chinese enterprises are encouraged to go global and have actively carried on various business cooperation with the countries along "BRI." However, with the prosperous development chances, Chinese enterprises have to face cross-culture conflicts due to different cultural environments such as multinational employees and differences in host country culture. Effectiveness in cross-culture conflicts is becoming the foremost challenge if Chinese enterprises want to achieve sustainable international business development. Furthermore, cross-culture conflict management's success is also crucial for people in the host countries to properly interpret China's "BRI" and then embrace it willingly.

Xi Jinping proposed that exchanges and mutual learning among civilizations should follow diversity, equality and inclusiveness. "Diversity" advocates building a world civilization composed of diverse cultures. "Equality" encourages equal exchanges and mutual learning between different cultures; "Inclusiveness" aims to achieve "coexistence of civilizations" through cultural exchanges and integration. Chinese enterprises consider these principles and are suggested to solve these cross-cultural conflicts harmoniously. Our study introduces Confucian culture into the management of cross-cultural conflicts. Especially the four core values, "He," "Ren," "Li," and "Zhongyong" proposed by Tsai et al. (2011), are precisely discussed. In combination with Hofstede's four dimensions, a theoretical research framework has been established to analyze how these Confucian culture values are integrated into the management of cross-culture conflicts for the Chinese enterprises going global. With the theoretical research framework's guidance, an empirical study has been done among Chinese multinational enterprises' cross-cultural employees.

The research findings put forward practical strategic suggestions on how the management takes advantage of the Confucian culture's essence to mitigate the cross-culture conflicts. Furthermore, this research also enriches cross-cultural conflict management literature from the new perspective of Confucian culture integration. Lastly, this study contributes to enhancing the mutual understanding of different cultures in different countries along "BRI." On the one hand, Chinese enterprises should advocate Confucian culture inside their companies and contribute Confucian culture wisdom to the global economy's development. On the other hand, Chines enterprises take the role of an ambassador of friendship for exchanges between China and foreign countries.

The rest of the paper is organized as follows. Section "Literature Review" reviews the previous papers. Section "Methodology and Data" explains the data and the methodology. Section "Findings' provides the findings. Section "Conclusion" concludes.

LITERATURE REVIEW

Cross-cultural conflict management in multinational corporations refers to managing business organizations and diverse employees of different national or cultural backgrounds. The related studies have tried to understand the effective business management mode or methodology of cross-cultural conflicts in the global context of different cultural communities with inter or cross-cultural conditions. Several papers have focused on national culture variables and further tried to provide insights or solutions for the enterprises' cross-cultural conflicts dilemma (Kogut and Singh, 1988; Jiang et al., 2016).

Cross-cultural management is an influential discipline, and several researchers have done studies on cross-cultural management issues. Hofstede (1980) conducted two-round questionnaire studies on IBM employees worldwide to understand the cultural differences and their impacts on values, behaviors, norms and institutions. Thus, the author proposed an analysis model of cultural dimensions, including power distance, uncertainty avoidance index, individualism vs. collectivism, and masculine vs. femininity. Later on, the author adopted other scholars' ideas to expand the model to cover another two dimensions of long-term vs. short-term and indulgence vs. restraint. Besides Hofstede's study, some other studies proposed that workplace cultural diversity was potentially beneficial, enhancing productivity and innovation. It could also intensify conflicts due to cultural clashes, such as the differences in values and working behaviors (Mannix and Neale, 2005).

This approach is also tested with the data for Chinese firms. Some Chinese researchers have focused on studying the multinational enterprises along "BRI," bridging and adjusting modes of cross-cultural conflict management. In general, these researches attached importance to cross-cultural conflict management. They attempted to propose modes and adjusted communication approaches that effectively resolved cross-cultural conflict issues for multinationals. It is found that foreign-invested companies should start from reality and construct a new business operation model in the local markets by integrating different cultural elements to their new corporate cultural norms, thus resolving the inner cross-cultural conflicts faced by these multinational group companies. For instance, Chin (2015) argued that harmony played an important role in promoting organizational citizenship behaviors in Chinese organizations, thus managing cross-cultural conflicts effectively. Lu et al. (2019) studied social responsibility toward the employees and career development sustainability during manufacturing transformation in China. They proposed that Chinese firms should establish a sustainable culture in their business operation facing globalization. Liu et al. (2020) explored the interactive effects of national culture differences and conflict management approaches on international construction joint ventures' performance.

To sum up, there are many valuable study findings of Confucian culture's role in modern business management and cross-cultural conflict management in the academic field both abroad and at home. However, so far, the studies concerning the feasibility of integrating Confucian culture in the cross-cultural conflict management of Chinese firms going global along "BRI" are still rare in academia. With these significant research findings as to the foundation, this study combines the Confucian culture with Hofstede's cultural dimension and further designs the questionnaires to conduct the empirical study.

METHODOLOGY AND DATA

The study adopts core Confucian culture values of "He," "Ren," "Li," and "Zhongyong" as four independent variables. It takes Hofstede's four culture dimensions of power distance, uncertainty, individualism vs. collectivism, and masculinity vs. femininity as four dependent variables, thus creating the theoretical analysis framework. The questionnaire design is based on the integration of Confucian culture into cross-culture conflict management as dependent variables. The questionnaire survey findings aim to examine the feasibility of integrating Confucian culture into handling the cross-cultural conflicts faced by Chinese enterprises going global along "BRI."

The employees of China's multinational corporations who have already got involved with multinational business operations along "BRI" are invited to participate in the questionnaire survey. These employees are from diversified positions, including first-line workers, line managers, general managers, directors and even the board members who have different nationalities and diverse national cultural backgrounds. These enterprises are large and well-established in each industry, mainly Huawei Technologies, Guangdong Import and Export, and Zhongxing Telecom Equipment.

The questionnaire is designed according to the integration of Tsai et al. (2011) four core Confucian values with Hofstede's four culture dimensions to fit the assumption of the specialty of research objects. The questionnaire consists of four parts. Part one is about demographic information collected to describe the survey participants' individual information, which helps investigate the potential influence of unique features on Confucian culture resolution to cross-cultural conflict management. The second part is about cross-cultural conflicts of business management, designed to figure out the forms, origins and others of cross-cultural conflicts, thus paving a foundation for the following parts. Part three is about the Confucian culture, examining the participants' cognition of Confucian culture and their assumption about the feasibility of integrating Confucian culture into cross-cultural conflict management. The final part is about the specific values of Confucian culture and whether the integration into cross-culture conflict management is effective or not. The questionnaire compilation fully takes the core Confucian culture values, Hofstede's four culture dimensions and diversity of cultural background mentioned above.

Before the full questionnaire survey, the pilot study is done by selecting 12 participants. We aim to determine the deviations in the questionnaire that do not accord with the actual situation and proofread them. Besides, the questions' wordings and orderings are adjusted to improve the quality of the questionnaire largely.

For convenience, the questionnaire survey is conducted through the online questionnaire APP, mainly by Wechat and email. The questionnaire APP is user-friendly, and the deadline is set to collect the well-done questionnaires from the participants. Because of the automatic recording of IP addresses, repetitions and invalid answers can be properly prevented. The survey finally collects 293 questionnaires from the participants, among which 264 are valid ones, with the ratio of collection reaching up to 90.1%. The left 29 questionnaires are invalid due to these reasons, incompleteness or the failure to open the documents. The following data analysis is done on 264 valid questionnaires.

FINDINGS

Reliability and Validity Tests

Reliability reflects the consistency and steadiness of the result of the test tool. It is the indicator of the tested samples' authentic characteristics. This paper mainly adopts the method of Cronbach α index with its value range between 0 and 1. When the α index is below 0.6, it is assumed that the validity is insufficient. If so, the questionnaire should be adjusted and improved. However, if the α index value is more than 0.6, it proves that the validity is of good effect. This study's question samples are tested with this method, and the test results show that Cronbach α indexes are all more than 0.80, and a majority of them are more than 0.90,

TABLE 1 | Reliability results of confucian cultural values.

Index (items: 4)	Cronbach's α value	
"He"	0.934	
"Ren"	0.927	
"Li"	0.920	
"Zhongyong"	0.898	
Samling Kaiser-Meyer-Olkin Measurement	0.957	
Bartlett's Degree of Sphericity	Chi-square Stat.	467.105
Degree of Freedom	120	
Significance	0.000	

TABLE 2 | Demographic information.

Demographic variable	Type	Number	Frequency
Gender	Male	182	68.94%
	Female	82	31.06%
Nationality	Chinese	216	81.82%
	Foreign	48	18.18%
Position	First line workers	99	37.50%
	Line managers	100	37.88%
	Directors or above	65	24.62%
Working time	<1 year	117	44.32%
	1–3 years	75	28.41%
	3–5 years	50	18.94%
	>5 years	22	8.33%
Company size	<50 people	56	21.21%
	50–200 people	92	34.85%
	200–500 people	51	19.32%
	>500 people	65	24.62%

The data is counted following the 264 valid questionnaires.

TABLE 3 | Cross-cultural conflicts in multinational enterprises.

Item	Content	Number	Frequency
Form	Employees' value deviation	203	76.89%
	Employees' habit deviation	167	63.26%
	Managers' leadership style deviation	152	57.58%
	Managers' decision style deviation	97	36.74%
	Others	13	4.92%
Origin	Value	209	79.17%
	Language barriers	163	61.74%
	Body language	55	20.83%
	Work habit	178	67.42%
	Time concept	86	32.58%
	Others	3	1.14%
Activeness in resolving cross-cultural conflicts	Less active	75	28.41%
	Active	173	65.53%
	Very active	16	6.06%

which shows that this survey's result is very reliable. The detailed test results are seen as follows in **Table 1**.

Validity is the tool for testing the accuracy of the result. The validity test mainly aims to justify the structural validity of the testing tool. Before the factor test is done, the research first uses KMO and Bartlett's statistical method to test each variable's coefficient. It is generally considered to be the better effect when the KMO value is closer to 1. It is in a very good effect when the value is more than 0.9. However, it is assumed to be in a poor effect when the value is less than 0.6. Furthermore, the validity test shows that the possibility of Bartlett's degree of sphericity is 0.000, less than 1%, indicating the correlation is very strong and available for factor analysis.

KMO's measured value is 0.957, which justifies that the factor analysis result is consistent. The Chi-square value of Bartlett's degree of sphericity in the measuring scale is 4,607.105, indicating that the research's questionnaire data is of high correlation.

Demographic Variables

The first part of the questionnaire survey is about the participants' demographic data consisting of gender, nationality, position, working time and company size. This data is very helpful to make clear the exact information of the surveyed participants. The detailed information is shown in **Table 2**.

We observe that the surveyed participants are more males than females in gender, among whom there are more Chinese than foreigners in nationality. The ratio of male vs. female is reasonable in multinational companies as international business requires more time and energy devotion while working in foreign countries. On this, the males have the advantages over the females. These surveyed companies are Chinese companies that are expanding the overseas market along "BRI." Although there are foreign employees in them, the majority of employees could be Chinese reasonably. As for their position, different levels' employees, including first-line workers, line managers and directors or above, took part in the questionnaire survey. Their working duration is from less than 1 year to at most 5 years. It is found that most of the participants have been working in these companies for less than 3 years. It is attributable to the specific industries in this survey. These companies are surveyed mainly in high-tech, trade or construction industries which highly requires updated expertise. Therefore, these companies annually recruit talented graduates from top Chinese universities to gain talents equipped with the updated information and cutting-edge technologies. Therefore, these workers are quite new in the companies. Moreover, the company size ranges from less than 50 people to more than 500 people, which is available for the study to examine the different sized companies' cross-cultural conflict management strategies. "BRI" encourages all sized companies who have the relative capabilities to go global and contribute to the development of countries all over the world.

The Cross-Cultural Conflicts in Multinational Enterprises

This part is designed to examine the forms and origins of cross-cultural conflicts in multinational companies. **Table 3** shows the top raking forms and origins among the employees in these multinational companies. Furthermore, the activeness of management in resolving these cross-cultural conflicts is investigated too.

The results show that there are major cross-culture forms in these companies. The top four forms are employees' value deviation, habit deviation, managers' leadership style deviation, and managers' decision style deviation. In terms of cross-cultural origin, value is also the most influential factor. Meanwhile, language barriers, body language, and work habits largely lead to misunderstandings or daily work conflicts. Regarding management's activeness in handling cross-cultural conflicts, 28.41% of employees are unaware of their management's actions to deal with cross-cultural conflicts. However, 71.59% admit that

TABLE 4 | Feasibility of confucian cultural values.

Sub-values of confucian cultures	N	Minimum value	Maximum value	Mean	Standard deviation
H1.Harmony: valuing the harmony atmosphere of firms	264	1	6	4.39	1.235
H2.Diversity: respecting different cultures and traditions of people	264	1	6	4.56	1.216
H3.Union: making profits with united hearts	264	1	6	4.42	1.215
H4.Peace: resolving cultural conflicts in a peaceful and friendly way	264	1	6	4.57	1.216
R1.Humanism: Caring employees in a humanistic way	264	1	6	4.41	1.133
R2.Love: showing managers' love to subordinates	264	1	6	4.47	1.123
R3.Equality: treating all in a way as you want to be treated	264	1	6	4.44	1.162
R4.Imitativeness: disciplining themselves with inner attitudes of activeness	264	1	6	4.42	1.171
L1.Politeness: treating diverse people in a polite way	264	1	6	4.67	1.054
L2.Rules-based: regulating people's behaviors based on rules and norms	264	1	6	4.46	1.136
L3.Self-awareness: strictly requiring themselves by exemplarily obeying rules	264	1	6	4.51	1.075
L4.No-prejudice: treating people of cultural diversity with no prejudice	264	1	6	4.63	1.050
ZY1.Moderation: managing cross-cultural conflicts in a moderate or participative way	264	1	6	4.27	1.144
ZY2.Flexibility: making and adjusting decisions according to changes and situations or in an innovative way	264	1	6	4.58	1.107
ZY3.Action-orientation: managing cross-cultural conflicts by doing rather than by saying	264	1	6	4.48	1.163
ZY4.Charity: interacting all cultures with social responsibility and kindness	264	1	6	4.47	1.113

the management is active or very active in resolving cross-cultural conflicts. This evidence implies that multinational enterprises attach much importance to cross-culture issues because they play a crucial role in performance success.

The Feasibility of Confucian Cultural Values

With the survey of the first three parts done, it can be concluded that the major cross-cultural conflicts are in the forms of employees' value deviation, employees' habit deviation, managers' leadership style deviation and decision style deviation etc. these conflicts are mainly attributable to the difference in value. Multinational enterprises are active in resolving these cross-cultural conflicts. On the assumption of the feasibility of integrating the Confucian culture, this study further explores what exact Confucian culture values can be taken to mitigate the cross-cultural conflicts (see **Table 4**).

Based on the four core values of Confucian culture, "He," "Ren," "Li," and "Zhongyong," this study refers to The Analects. It lists 16 sub-values of Confucian culture, which may be adopted to manage multinational companies' cross-cultural conflicts. The participants are asked to rate their feasibility ranging from the least feasibility (minimum value 1) to the most feasibility (maximum value 6). The results indicate these values are very feasible because their average mean is between 4.0 and 5.0, close to the maximum value of 6. There is no doubt that different values cause cross-culture conflicts. There is no possibility for the employees with different nationalities to unify their values. However, the survey implies that Confucian culture values can be integrated to the diversity of cultures and create a harmonious atmosphere in multinational enterprises, thus mitigating the conflicts and improving performance.

CONCLUSION

This study adopts both quantitative and qualitative research methods such as the questionnaire survey, the literature review, and the Cronbach α index method to explore the feasibility of integrating Confucian culture into cross-cultural conflict management. The findings are as follows: Firstly, the survey finds out the major forms of cross-cultural conflicts popularly recognized by employees in Chinese multinational enterprises. They are specifically employees' value deviation, habit deviation, managers' leadership style deviation, and managers' decision style deviation. And these cross-cultural conflicts' primary origins are recognized as value, language barrier, body language, etc. Furthermore, most questionnaire survey participants confess that their management has already recognized the importance of cross-cultural conflicts and is active in dandling them. Secondly, the questionnaire further discovers that more than half of the participants agree that integrating Confucian culture into cross-culture conflict management is feasible. With the coverage of four core values of Confucian culture "He," "Ren," "Li," and "Zhongyong," the related 16 sub-values are tested to be feasible in cross-cultural conflict management.

These findings first shed light on the existing literature as this study explores cross-culture conflict management from a new perspective beyond traditional researches. Moreover, the findings greatly contribute to Chinese multinational enterprises going global along "BRI." These enterprises should readjust their cross-culture conflict management by considering Confucian culture. The findings empirically show that Confucian culture can be integrated into diverse national cultures and is feasible in cross-culture conflict management.

Our findings imply that Chinese enterprises should consider new strategies to manage cross-culture conflicts, especially during the COVID-19 pandemic (Tang et al., 2021). First, the management of the enterprises values the importance of learning Confucian culture. Confucian culture should be treated as the root of the corporate culture. While going global along "BRI," enterprises have to encounter the challenges of cross-cultural conflicts. With Confucian culture support, enterprises may find more efficient ways to mitigate these cross-cultural conflicts, which may back up their sustainable global business operations success (Pan et al., 2021). Therefore, Chinese multinational firms need to learn the Confucian culture and apply it in cross-culture conflict management. Second, our study also proposes that the management should strengthen the training of intercultural communication ability. The training should incorporate the host countries' diverse cultures, the cultural shock encountered in the host countries, and the cross-cultural communication skills. This training will help multinational employees handle cultural diversity when exposed to a strange cultural environment. In doing so, multinational enterprises may have fewer cross-cultural conflicts while going global. Third, multinational enterprises should value the importance of diverse cultural elements. "BRI" proposes harmony without uniformity. Respecting different cultures and embracing diversity is the foundation of cross-cultural conflict management, which conforms to the values of "He," "Ren," "Li," and "Zhongyong" in Confucian culture. Chinese multinational companies going global along "BRI" are encouraged to take the local cultures' essence and actively integrate Confucian culture to resolve the cross-cultural conflicts.

The questionnaire data collected are all from Chinese multinational enterprises with international operations in foreign markets along "BRI." The data may be limited in that the scale and coverage of samples are still insufficient. Major participants are Chinese, and it is suggested to take more foreigners with diverse nationalities as the participants when a similar study is conducted. Future studies can enhance our findings by considering these issues.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The survey in this research has been approved by the Ethical Committee of Guangdong University of Foreign Studies. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

XL: writing original draft and data collection. WZ: writing original draft. YL: writing and reviewing original draft. All authors contributed to the article and approved the submitted version.

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BRIEF RESEARCH REPORT
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Investor Sentiment and Stock Returns During the COVID-19 Pandemic

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In this paper, we regard the Baidu index as an indicator of investors' attention to China's epidemic stocks. We believe that when seeking information to guide investment decisions, investor sentiment is usually affected by the information provided by the Baidu search engine, which may cause stock prices to fluctuate. Therefore, we constructed a GARCH extended model including the Baidu index to predict the return of epidemic stocks and compared it with the benchmark model. The empirical research in this paper finds that the forecast model including the Baidu index is significantly better than the benchmark model. This has important reference value both for investors in predicting stock trends and for the government's formulation of policies to prevent excessive stock market volatility.

Keywords: Baidu index, google trends, investor sentiment, epidemic stocks, forecast

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INTRODUCTION

Information has become one of the most valuable assets in the financial market. A growing body of literature shows that there is a complex correlation between information and financial market fluctuations. However, due to data limitations, most of the previous research has focused on the exploration of the role of micro-enterprise financial information. Many studies have also theoretically explored the importance of information to financial markets. With the popularization of mobile Internet, the emergence of big data information has completely changed the production, intermediary, dissemination, and consumption of information in the financial industry. Investors usually use enhanced information searches to cope with uncertainty and assist decision-making. The main advantages of using Internet searches are that they are free, wide-ranging, and timeliness.

The use of information obtained from search engines for stock market return forecasts is gradually gaining attention. The availability of big data brought about by search engines reinforces this trend. These data can usually provide investors with real-time information, thereby enhancing the scientific nature of investment decisions. In view of the gradual popularity of the mobile Internet, it has become a standard practice for most investors to seek online information before making an investment decision. Investors leave behind data about what they are looking for every time they use a search engine. If these retrieved data are analyzed systematically, investor sentiment in the real world can be effectively tracked. Therefore, the analysis of stock market dynamics usually depends on the availability of online information. Among them, the use of Google search data to predict epidemics, unemployment rates, and epidemiology is widely known.

Although Google ranks first in the global search engine market, it is unavailable to Chinese users. In China, investors usually use the Baidu search engine to retrieve data. This search engine's market

share ranks first in China. Therefore, it is reasonable to believe that the data provided by Baidu searches can reliably reflect the attention of Chinese investors. The Baidu Index is a tool similar to Google Trends, launched by Baidu to reflect the intensity and interest of users in searching for specific keywords. Unlike Google Trends' weekly data, the Baidu Index can obtain daily user retrieval data, but there is a fee to download this data. In the current context in which the COVID-19 epidemic has not yet been effectively controlled, the availability of such high-frequency data will not only assist consumers in making investment decisions, but also help government departments to monitor epidemic trends in real time, contributing to efforts to control the epidemic.

In the raging situation of the COVID-19 epidemic, most existing studies use Google Trends to analyze the epidemic's impact, predict its trends, determine the users' needs for epidemic prevention materials and information, and monitor epidemiological trends. There are also some studies using Google Trends to examine the impact of COVID-19 on the macro economy and the stock market (Szczygielski et al., 2021). However, studies using the Baidu index to examine the impact of investor sentiment on the returns of epidemic stocks are still rare. Although COVID-19 has dealt a huge blow to the tourism, hotel, and aviation industries, epidemic stocks such as anti-epidemic supplies and vaccines have benefited from this public health emergency (Wu et al., 2020). Using the Baidu index to proxy the information needs of investors based on Internet search volume and analyzing the impact of investor sentiment on specific stocks of the epidemic will not only help us to analyze the public's demand for epidemic materials and information, but to engage in real-time monitoring of the epidemic's trends and to improve the government's ability to respond and help in the economic recovery.

LITERATURE REVIEW

In recent years, some scholars have used Google Trends to study epidemics and disease spread. There are also some studies that predict financial markets based on Google Trends data, but the conclusions are inconsistent.

Yung and Nafar (2017) have investigated the impact of retail investor attention to the expected returns of real estate investment trust funds. The study found that the higher the interest of retail investors as measured by the Google Trends search volume index, the higher the expected return of real estate investment trusts. Swamy et al. (2019) use data from S&P BSE 500 companies listed on the Indian Stock Exchange from 2012 to 2017 to examine the effectiveness of investor attention as measured by the Google search volume index in predicting stock returns. The results of the study show that a higher Google search volume index can predict positive and significant earnings in the following 1–2 weeks. Higher quantiles of GSVI will produce higher excess returns.

Research by Vlastakis and Markellos (2012) shows that the demand for information is positively correlated with the volatility and trading volume of 30 major stocks traded on the New York Stock Exchange and Nasdaq. Takeda and Wakao (2014) also argue that the increase in search activity is related to the increase in trading activity, but the possibility that the increase in trading volume will cause the stock price to rise is not high. Da et al. (2011) found that the increase in the Search Volume Index of Russell's 3000 shares indicates that the stock price will rise in the next 2 weeks, and the price will eventually reverse within a year. The Search Volume Index has also brought large first-day earnings and long-term underperformance to many IPO stocks. Nguyen et al. (2019) even believe that the increase in Google search volume in the Philippines, Thailand, and Vietnam had a significant negative impact on stock earnings.

Preis et al. (2010) investigate the correlation between company name search volume and rate of return, but they did not find a significant correlation between the two. Instead, they found strong evidence that Google search data can be used to predict transaction volume. Kim et al. (2019) study the impact of Google searches on Norwegian stock market activity. They also find that Google searches have no correlation to abnormal returns over the same period or in the future. Fang et al. (2020) used Baidu keyword search volume data to improve the volatility prediction of the Chinese stock market. (Gozgor et al., 2019; Jiang et al., 2020; Liu et al., 2020; Fang et al., 2021a,b; Wu et al., 2021) discussed the impact of economic uncertainty, complexity, COVID-19 and globalization on the economy and financial markets.

VARIABLE DESCRIPTION AND STATISTICAL DESCRIPTION

In view of the data availability and habits of Chinese investors using search engines, we use the Baidu index to analyze investors' attention to information about the epidemic. For keywords related to the epidemic, we have selected representative terms such as "N95 masks," "Wuhan epidemic," "latest news about COVID-19," "medical masks," etc. We use N95, Wuhan, COVID-19, and Mask to represent the above variables, respectively. All keyword data are taken with natural logarithmic values. We selected Walvax, a listed company, as the research object for the stock return data of the epidemic. Walvax is a modern biopharmaceutical enterprise specializing in the research and development, and the production and sales of biological drugs such as vaccines and blood products in China. It is a nationally recognized high-tech enterprise and a national enterprise technology center. The company was listed on the Growth Enterprise Market of the Shenzhen Stock Exchange of China in November 2010. Its stock code is 300142. We use the following formula to calculate stock returns:

$$Return_{i,t} = \frac{(\text{Closing } price_{i,t} - \text{Closing } price_{i,t-1})}{\text{Closing } price_{i,t-1}} \quad (1)$$

In the above formula, Closing $price_{i,t}$ represents the closing price of stock i on day t. All stock return data are multiplied by 100.

Before exiting the Chinese market in 2010, Google ranked first in the Chinese search engine market. Since then, Baidu's market share has continued to rise from 60.2% in 2010 to 72.4% in May

TABLE 1 | Statistical description of the main variables.

	Return	N95	Wuhan	COVID-19	Mask
Mean	0.016	6.424	7.617	10.058	5.930
Median	0.096	6.417	7.617	10.041	5.872
Maximum	12.423	7.272	9.526	11.439	7.403
Minimum	−19.996	5.429	6.758	9.141	4.997
Std. Dev.	4.129	0.325	0.475	0.486	0.438
Skewness	−0.370	−0.500	0.744	0.625	0.641
Kurtosis	5.895	3.891	4.352	3.273	4.271
Jarque-Bera	68.468	13.739	30.971	12.536	25.008
Probability	0	0.001039	0	0.001896	0.000004
Sum	2.910	1182.072	1401.443	1850.660	1091.151
Sum Sq. Dev.	3119.236	19.308	41.262	43.163	35.151
Observations	184	184	184	184	184

TABLE 2 | Data stationarity test.

	ADF	PP
Return	−16.31137***	−16.31657***
N95	−3.686776***	−3.752247***
Wuhan	−3.711559***	−3.418142**
COVID-19	−2.856401*	−2.974697**
Mask	−3.359155**	−3.365990**

****, **, and * represent statistical significance at 1, 5, and 10% levels, respectively.*

2021 (Statcounter, 2021). In view of Baidu's leading position in the current Chinese search engine market, we choose Baidu Index instead of Google Trends as the source of search data to obtain investor sentiment (http://zhishu.baidu.com/).

The statistical description of the main variables is shown in **Table 1**. From the perspective of stock return, the maximum value is 12.423, which was obtained on February 10, 2021, and the minimum value is −19.996, which was obtained on December 7, 2020. Among all search keywords, "latest news about COVID-19" has the largest average value, because investors will continue to pay attention to the progress of the epidemic. The keyword "medical masks" has the smallest mean value, because investors' attention to medical masks has declined as the epidemic in China was quickly brought under control.

EMPIRICAL RESEARCH

Before empirical research, we need to test the stationarity of the data. We use ADF and PP tests to investigate the stationarity of the data, and the test results are shown in **Table 2**. The test results show that there is a unit root in the time series of stock closing prices. But the stock market return rate has overcome this problem because of the differential. **Table 2** shows that both Return and N95 variables passed the 1% significance test. The remaining variables have passed the 10% statistical test. This shows that all time series are stationary.

The forecast error of financial time series usually has heteroscedasticity. The size of the residual is related to the most recent residual value. Ignoring the effects of ARCH may lead to reduced effectiveness. We use the ARCH LM method to test the ARCH effect.

The null hypothesis of the ARCH LM test is: there is no ARCH effect up to the order in the residual sequence, and the following regression is required:

$$\hat{u}_t^2 = \alpha_0 + (\sum_{s=1}^{p} \alpha_s \widehat{u}_{t-s}^2) + \varepsilon_t \quad (2)$$

In formula (2), $\hat{u}_t$ represents the residual. Under the null hypothesis, the exact finite sample distribution of the F statistic is unknown. LM test generally follows the χ^2(p) distribution gradually.

The test results are shown in **Table 3**. The LM test results show that the null hypothesis is rejected at a significance level of 10%, indicating that the residual sequence of formula (2) has an ARCH effect. In addition, from the perspective of the fluctuation of the residual square, it also has the characteristics of time varying and clustering, which is suitable for modeling with a GARCH model.

Since many asset prices are conditionally heteroscedastic, GARCH is widely used in the financial industry. We first estimate the GARCH(p,q) model, and then select the appropriate number of lag periods based on the AIC value of the variance equation. The estimation results show that GARCH(1,1) can better describe this process. Therefore, we choose the following benchmark model:

$$\sigma^2 = \omega + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (3)$$

Given that the investor sentiment represented by Baidu search keywords may affect stock returns, we add the Baidu Index variable to the above formula (3) to extend the benchmark model. But we need to first determine the lagging term of the Baidu Index. The estimation results show that selecting the lag period 0 can pass the 1% significance test. This is mainly because the Baidu Index search terms are based on days and are reflected in real-time. In other words, the investor sentiment reflected in the Baidu Index may be reflected in the stock market returns of the day. To this end, we establish the following extended GARCH model including the Baidu Index:

$$\sigma^2 = \omega + \alpha_1 u_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \gamma LnBaiduIndex \quad (4)$$

Based on the extended model of Equation (4), we use the one-step forward method to predict the return of epidemic stocks. The entire sample period covers March 4, 2020 to March 9, 2021. We first use the time series data from March 4, 2020 to September 6, 2020 to estimate the model, and then we use the above model to predict the variance on September 7, 2020. We continue to repeat the above steps, using the one-step forward method, to predict the variance of the entire sample period. At the end of the sample period, we can use the prediction error to judge the prediction accuracy of the model.

TABLE 3 | LM test results.

Breusch-Godfrey Serial Correlation LM Test:			
Null hypothesis: No serial correlation at up to 1 lag			
F-statistic	3.486551	Prob. F(1,245)	0.0631
Obs*R-squared	3.535849	Prob. Chi-Square (1)	0.0601

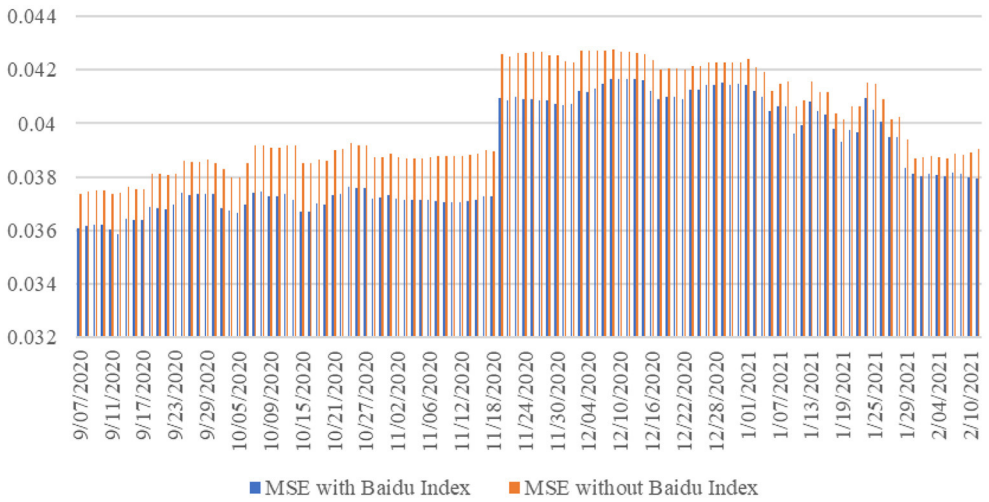

FIGURE 1 | MSE of the benchmark and extended models.

The prediction error value of a model is the difference between the actual model and the conditional variance of the predicted value. The forecast results are shown in **Figure 1**. Overall, the extended model with the Baidu index has smaller prediction errors. Our research also finds that in periods of high volatility, neither the benchmark model nor the extended model with the Baidu index can explain its variance well. The main reason is that in the period of market turbulence, investors tend to search for information and buy or sell stocks, which leads to substantial turbulence in stock returns.

To accurately calculate the degree of improvement in the prediction accuracy of the extended model relative to the benchmark model, we calculate the root mean square error of the two models. The calculation results show that, compared with the benchmark model, the extended model with the Baidu index reduces its root mean square error by an average of 3.16%. We also divide the entire sample period into a period of high volatility and a period of low volatility. High volatility refers to the period when the conditional variance exceeds the mean. Low volatility refers to periods that are below average. The results of the study show that during periods of high volatility, the number of searches on the Baidu index is also higher. This shows that in turbulent phases of the market, investors increase their information searches to assist in decision-making to avoid risks. This sentiment is directly reflected in the increase in transaction volume. In addition, the calculation results show that the degree of MSE decline in high volatility periods is more significant. Overall, regardless of the period, the extended model including the Baidu Index has greater prediction accuracy than the benchmark model. This shows that the extended model that includes the Baidu index is more suitable for predicting the returns of epidemic stocks. In other words, given the real-time nature of investor retrieval data, investor sentiment can be reflected in epidemic stocks in a timely manner. This has a shorter time lag than the previous official release of data with a significant lagging period on stock prices. Regardless of whether we consider investors or market regulators, including real-time investor sentiment into the prediction model will help improve investment returns or predict the direction of the stock market in real time. Incorporating diversified big data into stock and financial market analysis has become a standard practice.

CONCLUSIONS

In stock investment, although professional investors will monitor the leading index, this approach is largely inaccessible to retail investors due to cost and ability. In the raging situation of the COVID-19 epidemic, once a drastic change in the epidemic is discovered, investors may use search engines such as Google and Baidu as a source of information to assist in investment decisions. Epidemic data obtained by using the Baidu index can well represent investor sentiment and concern about epidemic stocks. After searching for relevant information on stocks related to the epidemic, investors may take investment actions immediately or the next day to affect stock returns.

In this paper, we use Baidu index data to measure investors' interest in searching for stock information about the epidemic. We find that during periods of severe market turbulence,

investors' attention to the stock market increases substantially. To avoid risks, investors tend to increase the trading volume of stocks, which leads to large fluctuations in stock prices. By incorporating the Baidu index into the extended GARCH model, we find that investor sentiment is reflected in the stock returns of the epidemic in a timely manner. Especially in periods of market turbulence, the model including the Baidu index can significantly improve forecasts. Therefore, investor sentiment reflected in search engine data constitutes a valuable source of information for predicting future volatility. Such real-time information can improve investor returns and help regulators to monitor the trends of the epidemic in real time. This provides information and decision-making reference points for controlling the epidemic and judging the demand for epidemic prevention materials. Under the COVID-19 pandemic, we can also predict the outbreak of the epidemic and the demand for medical supplies in advance by monitoring investors to search for keywords, and provide a scientific basis for the formulation of a vaccine plan.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: index.baidu.com.

AUTHOR CONTRIBUTIONS

BJ: writing—original draft. HZ: writing—review. JZ: investigation and design. CY: draft writing and software. RS: editing. All authors contributed to the article and approved the submitted version.

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ORIGINAL RESEARCH
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The Role of CSR Engagement in Customer-Company Identification and Behavioral Intention During the COVID-19 Pandemic

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The global coronavirus pandemic has reignited a strategic debate among the business community of the necessity for corporate social responsibility (CSR) engagement in the ever-dynamic social media. Considering the global economic downturn introduced by the COVID-19 pandemic, the present research is devoted to investigating whether CSR engagement in social media can help DiDi (a Chinese shared brand) at stake survive this overwhelming crisis. A theoretical model proposed to describe the hypothesized relationships was tested by a Structural Equation Modeling technique through the empirical online questionnaire. Through findings, we demonstrated that there was a positive relationship between CSR engagement of DiDi on WeChat, customer–company identification (C–C identification), and behavioral intention [purchase intention, brand loyalty, and e-word-of-mouth (eWOM)] of customers. With attention to psychological influence, our empirical statistics also evidenced the mediating role of C-C identification between CSR engagement and behavioral intention of customers. This study highlights the significant role of CSR engagement in a critical period theoretically and offers businesses more open innovation strategies to compete against the COVID-19 pandemic-induced market downturn.

Keywords: CSR engagement, behavioral intention, C-C identification, Chinese shared brands, COVID-19 pandemic

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INTRODUCTION

The practice of corporate social responsibility (CSR) with the actual positive impacts has been increasingly incorporated into the strategic movement of business operations (Lii and Lee, 2012; Hu et al., 2019). The European Commission (2011) theorizes that CSR initiatives refer to the integration of the companies of social and environmental concerns into their business operations. In addition to CSR initiatives, successful CSR engagement also requires the company to effectively communicate their CSR activities with their stakeholders through various platforms (Fatma et al., 2020). In general, CSR engagement by business organizations is supposed to effectively affect the behavioral intention of the consumers, which can eventually contribute to the increased economic benefits (Sharma et al., 2018; Puriwat and Tripopsakul, 2021). In regardless of the favorable outcomes of CSR engagement, discrepancies occur in the academic world that whether CSR

engagement is of necessity in a critical period, e.g., COVID-19 (Han, H. et al., 2020; Bae et al., 2021; Puriwat and Tripopsakul, 2021). Since this type of activity requires companies' investment of their limited available capitals that are might needed by other promotional activities as well.

Social media are experiencing a booming development with the advent of information and technology, drastically changing the communication landscape where people interact with each other. Owing to its easy accessibility, people are increasingly involving themselves in this environment, contributing to the great prevalence of social media (Du and Vieira, 2012; She and Michelon, 2019). In particular, the sudden outbreak of the COVID-19 pandemic has furthered a digitalized transformation of human interaction where there is a reported increase in the users of social media (Lep et al., 2020; Vanko et al., 2021). Meanwhile, social media can be utilized by companies to extend businesses to a wider audience with a global reach and affect the behavioral intention of consumers while engaging in their CSR initiatives (Bialkova and Te Paske, 2020; Kuhzady et al., 2020). However, through a review of a study, the academy concerning CSR practices lags behind the practices of CSR engagement through social media (Kesavan et al., 2013; Chu et al., 2020). Among these studies, there is also a lack of explorative insights specifying the underlying psychological mechanism of how CSR engagement affects the behavioral intention of customers online in a specific period (Ahearne et al., 2005; Han, H. et al., 2020). Nonetheless, it has been acknowledged that psychological experience is indispensible for the illustration of human reasoned behaviors (Warshaw and Davis, 1985; Tomczyk et al., 2020).

Shared brands as a new pattern of business operation are reported as seriously short of CSR engagement even when staying in an optimistic context (Bhappu and Schultze, 2019). Toward the conceptualization of this emerging economy, a consensus is that it advocates for peer-to-peer collaborative consumption and better use of idle resource based on advent technology (Hu et al., 2019; Kuhzady et al., 2020). Regardless of being viewed as a pathway to sustainability, criticism on shared brands claims that its unregulated system backfires on a sustainable ideal, contributing to even serious over-consumption (Martin, 2016; Bhappu and Schultze, 2019). Nonetheless, these new consumption platforms based on collaborative consumption are heralded to become a dominant business system in the future (Heinrichs, 2013; Martin, 2016). Regarding the contradictory nature of shared brands, to the best of our knowledge, there are no studies that explored the CSR engagement by shared brands to find out the possible solutions (Bhappu and Schultze, 2019; Hu et al., 2019).

In a nutshell, to fill these identified voids, this study dissected the psychological process of customers toward the effects of CSR engagement by shared brands at a time that the communication landscape has been transforming into an ever-digitalized one during and after the COVID-19 pandemic. More precisely, in light of the changes happening in the way people interact with others during the coronavirus pandemic, this study is devoted to investigating whether and how CSR engagement of DiDi (a Chinese shared brand) on WeChat can exert its impacts on the behavioral intention of customers. Besides, given the dominant role of customer–company identification (C-C identification) in exploring the psychological state of customers, this study is also concerned with its operation underlying such impact of CSR engagement. Overall, this study in nature focused on the relationships among CSR engagement of DiDi, C–C identification, and behavioral intention of customers in an era of the COVID-19.

LITERATURE REVIEW

CSR Engagement of Companies *via* Social Media

Apart from economic agendas, companies nowadays have increasingly assumed much importance on CSR engagement, which is viewed as a strategic movement for their business development (Kesavan et al., 2013; Puriwat and Tripopsakul, 2021). According to Fatma et al. (2020), CSR engagement is related to how companies perform and communicate their CSR-related activities. In this way, on one hand, companies directed at CSR engagement should practice their own CSR initiatives beyond economic benefits (He and Li, 2011; Puriwat and Tripopsakul, 2021). On the other hand, alike CSR initiatives, equally important for companies is to ensure that CSR-related information is communicated to stakeholders, which is referred to as CSR communication (Oh and Ki, 2019; Fatma et al., 2020).

Scholars have evidenced CSR engagement in the study whereby companies can reap a myriad of benefits, for example, enhanced impression management and positive behavioral intention of customers, such as positive word-of-mouth (WOM) (Kesavan et al., 2013; Abitbol and Lee, 2017; Sharma et al., 2018; Puriwat and Tripopsakul, 2021). Most notably, it arises as a heated issue whether these positive effects from CSR engagement can be stimulated as well in a critical period, for instance, the global economic recession introduced by the COVID-19 (Puriwat and Tripopsakul, 2021; Vanko et al., 2021). Therefore, discrepancies occur concerning the necessity of organizational efforts in CSR engagement when the available capitals for economic agendas are simply not enough in times of crisis (Han, H. et al., 2020; Bae et al., 2021).

In the era of web 2.0, there is a paradigm shift that social life has gradually transformed into a digitalized model with the involvement of social media (Vanko et al., 2021). These emerging social platforms exhibit their great potentials to generate more dialogic dynamics through which individuals can have more access to organizational information and even share their attitudes with fewer constraints (She and Michelon, 2019; Fatma et al., 2020). The physical disconnect with the society caused by the coronavirus has further accelerated the use of social media by which people keep in touch with the outside (Lep et al., 2020; Hayes and Clerk, 2021; Puriwat and Tripopsakul, 2021). With regard to the ever-digitalized social life, the emerging social media afford companies more possibilities to promote their CSR-dedicated activities, which, in turn, can help companies maximize their benefits from CSR engagement if used effectively (She and Michelon, 2019; Bialkova and Te Paske, 2020).

As indicated by Chu and Chen (2019), considerable research studies on CSR engagement have majorly discussed it in the traditional environment, for example, corporate websites. Among these studies, the positive effect of such an issue on the behavioral intention of customers has been continuously stressed. Nonetheless, how do social media empirically interplay with CSR engagement has relatively been an under-researched issue in the study regardless of its actual prevalence (Chu and Chen, 2019; Chu et al., 2020; Fatma et al., 2020). Furthermore, there is an identified gap regarding the underlying psychological process of how CSR engagement of companies affects the behavioral intention of consumers in social media (Lii and Lee, 2012; Martínez and Rodríguez del Bosque, 2013; Puriwat and Tripopsakul, 2021). Thus, in light of the increasingly digitalized world, this study investigates the psychological mechanism of whether and how the behavioral intention of consumers can be empirically influenced by the CSR engagement of companies in social media during the damaging COVID-19 pandemic.

CSR Engagement of Different Brands

Regardless of the general criteria offered to guide CSR engagement of consumers, existing research studies also suggest that discrepancies may occur while being examined in different industrial contexts (Fatma et al., 2018; White and Alkandari, 2019; Chu et al., 2020). More specifically, scholars perceive CSR engagement in nature as a context-based notion that cannot be separated from contextual considerations across culture and industry. In CSR academia, there is a mixed finding regarding the influence of CSR engagement on the behavioral intention of consumers where companies from different countries and industries had been examined (Fatma et al., 2018; Chu et al., 2020).

The digitalized life supported by advanced information and technology has nudged the development of shared brands, that is, not merely limited to information sharing (Kuhzady et al., 2020). The conceptualization of shared brands indicates further openness through which individuals can enjoy and participate in the production of service and products, such as houses, cars, and charge pals (Martin, 2016). The new pattern of shared brands motivated by sustainability is experiencing remarkable growth in the global market, even threatening the existence of traditional industries and heralding a new way to sustainability (Heinrichs, 2013; Martin, 2016). Nonetheless, amid great commercial achievement, the pattern of shared brands has also been continuously critiqued as disruptive and sometimes destructive toward society, which highlights solutions from academic discussions (Bhappu and Schultze, 2019; Galati et al., 2019). One of the typical case is the safety problems of Airbnb introduced by its unregulated system, a peer-to-peer platform through which individual can enjoy and provide apartment rental services (Martin, 2016). Toward the current dilemma confronted by shared brands, one of the solution advanced by researchers is CSR engagement whereby practitioners can optimize business activities of the shared brands (Bhappu and Schultze, 2019; Hu et al., 2019).

In terms of the context-based characteristics of CSR engagement, extant studies have typically considered its effect on the behavioral intention of consumers in the context of audit institution (She and Michelon, 2019), bank (Brammer et al., 2007; Puriwat and Tripopsakul, 2021), and hospitality (Fatma et al., 2018; Han S. H. et al., 2020; Puriwat and Tripopsakul, 2021). Despite the acknowledged importance of CSR engagement, there are few existing studies that have focused on the role of CSR engagement of shared brands (Hu et al., 2019). Given the increasing prevalence of shared brands, this study is devoted to discussing the CSR engagement of Chinese shared brands in such a critical period as the pandemic COVID-19.

HYPOTHESIS DEVELOPMENT AND CONCEPTUAL FRAMEWORK

CSR Engagement and C–C Identification in Social Media

Customer–company identification dependent on social identity theory generally illustrates the psychological state of consumers toward a company (Atakan-Duman and Ozdora-Aksak, 2014; Fatma et al., 2018). Based on social identity theory, it claims that people tend to locate and define themselves into specific social categories after a cognitive categorization process, when they find some similarities and overlap with the compared group (Tajfel and Turner, 1979; Bi et al., 2018). In this way, C–C identification can be ascribed as a specific social categorization after which customers attempt to build a strong emotional attachment toward a company (Fatma et al., 2018, 2020; Chu and Chen, 2019). When customers identify with their target groups, a sense of belonging will be instilled into their mind (Chu and Chen, 2019).

Among the special projects to identify probable consumers, CSR engagement is supposed to be of great value during such a process (Bhattacharya and Sen, 2003; Lii and Lee, 2012; Fatma et al., 2020). Through CSR engagement, companies, in general, are showing their commitment to the welfare of society, which, in turn, is more likely to satisfy the self-need of customers. In a similar vein, the previous studies have demonstrated that C–C identification can be stimulated when an organization is perceived as a socially responsible citizen by their customers (Bhattacharya and Sen, 2003; Lii and Lee, 2012). In comparison to the traditional communication landscape, the digitalization of social life empowers people to be more actively involved in the activities of companies instead of mere passive recipients (Chu and Chen, 2019; Fatma et al., 2020). Therefore, from a theoretical perspective, companies through these emerging social media (e.g., *Twitter*, *Weibo*, and WeChat *Official Account*) can increase consumer awareness about their CSR engagement effectively, which, in turn, can have a positive influence on C–C identification in such context.

For the above discussion, it was expected in this study that CSR engagement of shared brands in social media could affect their C–C identification during the pandemic COVID-19, which is represented as H1:

Hypothesis 1: There is a positive relationship between CSR engagement of the shared brands in social media and the C–C identification during the pandemic COVID-19.

Customer–Company Identification and Behavioral Intention of Consumers in Social Media

Behavioral intention as a dominant motivator of human reasoned behavior is defined as "*the degree to which a person has formulated conscious plans to perform or not perform some specified future behavior* (Warshaw and Davis, 1985, p.124). Similarly, Fishbein and Ajzen (1975) claimed that behavioral intention as a psychological outcome can be a strong predictor of the actual future behavior of an individual. Toward the regular items adopted for the measurement of the behavioral intention of customers in social media, existing studies suggest that three constructs should be incorporated: brand loyalty, purchase intention, and e-word-of-mouth (eWOM) (Chang, 2016; Chu and Chen, 2019). Brand loyalty refers to the deeply held commitment of customers toward a company, its service, or product, which can increase the economic profit of companies, especially in a critical period (Fatma et al., 2018; Han et al., 2019). In view of the overwhelming coronavirus-induced economic downturn, brand loyalty of customers then should be highlighted as a crucial asset that assists companies in competing against the competitive but shrinking market in the unfavorable external environment. It is noteworthy that Fatma et al. (2018) suggested that the evaluation of brand loyalty necessitates a two-fold consideration including attitudinal and behavioral loyalty. The loyalty of the consumers at the level of attitude on social media refers to a favorable attitude toward the company, which can lead to positive eWOM (Bhattacharya and Sen, 2003). Meanwhile, behavioral loyalty generally emphasizes the practical effects on purchase intention, which results in the monetary spending behaviors of patronages (Sharma et al., 2018; Chu and Chen, 2019).

In view of reasons behind these behavioral intentions, Ahearne et al. (2005) through empirical studies have evidenced that C–C identification is in essence an underlying psychological driver. With stronger C–C identification, it is suggested that customers will emotionally attach themselves to the company, which, in turn, can promote them to develop and safeguard this company in social media (Bhattacharya and Sen, 2003; Chu et al., 2020). In this regard, customers identified with a company will show more willingness to build long-term and loyal relationship with it (Bhattacharya and Sen, 2003; Fatma et al., 2020), to make repurchases (Ahearne et al., 2005; Martínez and Rodríguez del Bosque, 2013), and to disseminate its positive WOM voluntarily in social media (Chu and Chen, 2019).

For this, our study argued that with stronger C–C identification, Chinese shared brands could impact the behavioral intention of their customers positively during the COVID-19 pandemic, which was proposed as H2. It further postulated that brand loyalty plays a dominant role in the framework of behavioral intention of customers, which constitutes hypothesis 3. More precisely, it was indicated that brand loyalty of Chinese shared brands is positively related to purchase intention and eWOM of their customers in social media.

Hypothesis 2: There is a positive relationship in social media between C–C identification and (a) purchase intention, (b) brand loyalty, and (c) eWOM in social media of the shared brands during the pandemic COVID-19.

Hypothesis 3: There is a positive relationship in social media between brand loyalty of the shared brands and (a) purchase intention and (b) eWOM in social media during the pandemic COVID-19.

The Mediating Effect of C–C Identification Between CSR Engagement and Behavioral Intention in Social Media

Based on social identity theory, CSR engagement has shown its great potential to get C–C identification with which customers have the propensity to build an emotional and psychological link with the company (Fatma et al., 2018, 2020; Chu and Chen, 2019). Subsequently, customers with a strong C–C identification are meanwhile prone to extra-role behaviors that are "directed toward preserving, supporting, and improving the organization" (Ahearne et al., 2005, p.577), for instance, brand loyalty and eWOM (Bhattacharya and Sen, 2003).

Prior studies have evidenced that the behavioral intention of customers is a significant analytic point to illustrate the outcome of CSR engagement of business organizations (Zeithaml et al., 1996; Fatma et al., 2018; Puriwat and Tripopsakul, 2021). Moreover, C–C identification as an antecedent can offer a more detailed interpretation of the psychological process of how the behavioral intention of customers is gradually formulated (Bhattacharya and Sen, 2003; Martínez and Rodríguez del Bosque, 2013). Therefore, this study aims to externalize the internal logic between the CSR engagement and the behavioral intention of customers, where C–C identification is supposed to play a mediating role from the perspective of psychological analysis. In this regard, the following hypothesis was proposed:

Hypothesis 4: C–C identification mediates the relationship between CSR engagement of the shared brands in social media and behavioral intention during the pandemic COVID-19.

Based on the above arguments, this study then proposed a research framework that describes the hypothesized relationship among CSR engagement of shared brands, C–C identification, and behavioral intention in social media. **Figure 1** presents the theoretical framework in this study.

METHODOLOGY

The advent of information and technology is giving rise to a new pattern of business operation as shared brands and human interaction on social sites, such as Facebook and WeChat (Kuhzady et al., 2020). Social media have experienced a booming development in China where the Chinese companies and customers are becoming more active in the virtual community (Chu and Chen, 2019). Furthermore, the vitality of social media has ever been strengthened while people are encouraged in home quarantine during the COVID-19. Of the various social media in China, WeChat is one of the most popular platforms in the circumstance that Facebook and Twitter are not accessible

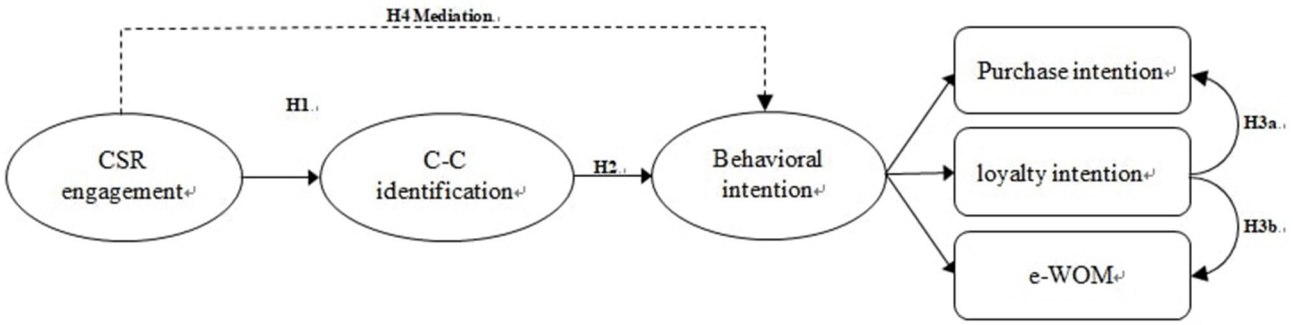

FIGURE 1 | The proposed theoretical framework and hypothesis.

to the Chinese. According to the financial report of Tecent, there was a sum of 12.25 billion users on WeChat up to the year 2020 (Tecent Holdings Limited, 2021). Compared to the statistics of 2019, it indicates an ever-digitalized evolution of the communication landscape during the coronavirus crisis. Together with the great economic performance Chinese shared brands have achieved, this study, therefore, is committed to the effect of its CSR engagement through WeChat on the behavioral intention of customers during the COVID-19. Of the various sharing industries in China, DiDi as a Chinese car-sharing platform was finalized for the research design that featured on the top 10 list of global unicorns maintained by *CB Insights* (https://www.cbinsights.com/research/infographics/) in 2020.

An online survey organized through Sojump (http://www.sojump.com/) was distributed to gather more responses from the target groups, lasting from January 12, 2021 to April 31, 2021. To reduce common method bias, an anonymous promise was also guaranteed during the whole study. After data filtering, 241 valid surveys were received in this study, which is considered as adequate for the analytic procedure (Kline, 2011).

Research Design and Measurement Generation

To obtain an initial insight of subordinate measurement items under each construct, the researcher reviewed the study related to CSR engagement, C–C identification, and behavioral intention. A draft questionnaire was developed incorporating the most prevalent measurement items in extant studies, which can strengthen the content validity of the research design (Shah and Ward, 2007; Kuhzady et al., 2020). The CSR engagement in the questionnaire was assessed by a three-item scale offered by Martínez and Rodríguez del Bosque (2013). C–C identification was evaluated by a four-item scale from Mael and Ashforth (1992). Brand loyalty was measured by a four-item scale from the study of Zeithaml et al. (1996). Purchase intension, meanwhile, was calculated with a three-item scale from Kang and Hustvedt (2014). eWOM was then measured by a three-item scale, adopted from Chu and Chen (2019). In light of the impact of industrial difference on the measurement items, a deep interview with two relevant experts was conducted whose suggestions were incorporated to refine the measurement contents. In this way, 17 items were determined as the initial measurement tools of our own research model.

After that, this study adopted a 7-point Likert scale to evaluate all items for a comprehensive understanding ranging from strongly disagree (1) to strongly agree (7). Before the main survey was administrated, this study also performed a pilot study with a sample size of 20 participants to confirm the suitability and understandability of the questionnaire. Through analysis, its result showed that there were two items from purchase intention and brand loyalty with the factor loading <0.5, which were then removed from the final questionnaire. **Table 1** summarizes the final structure of our measurement construct, which in total incorporated 15 measurement items.

The main content of the questionnaire was organized into two parts. The first part was majorly concerned with a general demographic picture of the respondents, including their age, gender, occupation, and city. The second part of the survey was designed to explore the attitudes of the participants toward each measurement item based on the 7-point Likert scale, which were tested as follows.

Sample and Data Collection

To sample which respondents to be included in this study, a purposive sampling technique was adopted to assure their representativeness. Accordingly, to more precisely describe how the CSR engagement of DiDi is operationalized on WeChat, the questionnaire also set several screening questions that remove respondents from being not involved in this process. To guarantee the representativeness of the respondents, interviewees at first were required to answer three questions, (1) Have you ever used DiDi in your life through WeChat small program? (2) Are you a follower of WeChat official account of DiDi? (3) Are you a follower of WeChat channel account of DiDi? Only respondents who answered "yes" toward either question were allowed moving on to the main questionnaire. An operational definition of CSR and its empirical cases was also provided at the beginning of the questionnaire. More precisely, participants read: "CSR is an organizational effort into social and environmental issues that goes beyond their economic profit. For example,

TABLE 1 | Description of measurement constructs and items.

Constructs	Items	Observed variables	Source
CSR engagement	CSR1	During the pandemic COVID-19, DiDi is committed to donation activities.	Martínez and Rodríguez del Bosque, 2013
	CSR2	During the pandemic COVID-19, DiDi uses part of its budget to assist the community in which it operates.	
	CSR3	During the pandemic COVID-19, DiDi is an environmentally responsible corporate.	
Customer-company identification	CCI1	When someone praises DiDi, it feels like a personal compliment.	Mael and Ashforth, 1992
	CCI2	When someone criticizes DiDi, it feels like a personal insult.	
	CCI3	I'm very interested in what others think about DiDi.	
	CCI4	When I talk about DiDi, I usually say "we" rather than "they."	
Brand loyalty	BL1	I prefer to use DiDi as my first choice as compared to other car-hailing apps.	Zeithaml et al., 1996
	BL2	I will consider DiDi as my main car-hailing app in the next few years.	
	BL3	It would be costly of time and money to end my relationship with DiDi.	
Purchase intention	PI1	I will consider using DiDi the next time I need car-hailing service.	Kang and Hustvedt, 2014
	PI2	I will use DiDi the next time I need car-hailing service.	
E word-of-mouth	eWOM1	I am willing to sat positive things of DiDi in social media.	Chu and Chen, 2019
	eWOM2	I will recommend DiDi to my friends and relatives in social media.	
	eWOM3	If my friends are looking for car-hailing service, I will encourage them to be a customers of DiDi.	

Meituan offers contactless delivery service during the COVID-19, ensuring the safety of their customers and man for delivery. Another one is Alipay issues the Ant Forest project designed for reducing carbon emission." After that, the participants were required to recall their experience concerning with how they perceive the CSR-related information of DiDi on WeChat while filling the questionnaire.

RESULTS

Sample Profile

Table 2 summarizes the descriptive demographic information of the respondents in the main survey through SPSS 22. Among them, it could be observed that 40.66% of them were men, and 59.34% of them were women. In all, the majority of them were students (41.91%) and working employees (30.29%).

TABLE 2 | Profile of the respondents.

Item	Description	Sample	%
Gender	Male	103	40.66
	Female	146	59.34
Age (years)	18–24	124	51.45
	25–34	57	23.65
	35–44	34	14.11
	45–54	18	7.47
	55 or above	8	3.32
Occupation	Individual business	23	9.54
	Freelancer	10	4.14
	Working employees	73	30.29
	Students	101	41.91
	Others	34	14.11
City	Guangdong	80	33.2
	Hubei	69	28.63
	Hunan	43	17.84
	Jiangsu	32	13.28
	Others	17	7.05

Measurement Model

Before testing the proposed theoretical model, all the constructs and their corresponding subscales were assessed to ensure their validity and reliability with the assistance of SPSS 22 and AMOS 26.

Reliability Test

To test the scale reliability of each construct, the value of Cronbach's alpha was calculated through SPSS 22, whose results are presented in **Table 3**. All coefficient alphas ranging from 0.823 to 0.94 were far higher than the recommended value of 0.7 according to Nunnally (1978), indicating the adequate consistency of the internal items in this study and the desired reliability of the measurement model.

Validity Test

Apart from reliability test, the researcher also examined the scale validity from two aspects: content validity and construct validity. With regard to the content validity, the measurement development was first based on a review of a mature study from which the most prevalent scales were adopted (Shah and Ward, 2007; Kuhzady et al., 2020). Furthermore, in consideration of

TABLE 3 | Reliability test.

No.	Constructs	Items	Cronbach's alpha
1	CSR engagement	3	0.929
2	C-C identification (CCI)	4	0.94
3	Brand loyalty (BL)	3	0.883
4	Purchase intention (PI)	2	0.823
5	E-word of mouth (eWOM)	3	0.916

the industrial and national difference, several amendments were conducted through the interview and pilot study.

An exploratory factor analysis (EFA) together with a confirmatory factor analysis (CFA) was performed to examine the construct validity in this study. In the phrase of EFA, the KMO sampling adequacy and Bartlett's test of Sphericity were first assessed. The value of KMO = 0.939 was well above the threshold value of 0.70 according to Sreejesh and Mohapatra (2013). Meanwhile, the results from Bartlett's test also indicated good significance based on the value of approximate chi-square = 3615.02 and $p = 0$. All statistic data hence showed favorable suitability of the present measurement model for path analysis.

To further confirm the results of EFA, a CFA examining the convergent validity and discriminant validity was also performed, where most indexes indicated a satisfactory fit of the measurement model (CMIN = 133.523, df = 77, CMIN/df = 1.734, GFI = 0.932, RMSEA = 0.055, CFI = 0.984, and NFI = 0.964). According to Awang (2015), there are normally three indexes of convergent validity while the correlations inside each construct is assessed: factor loading, average variance extracted (AVE), and composite reliability (CR). For a measurement model with good convergent validity, it is suggested that the cutoff value should be higher than 0.7, 0.5, and 0.7, respectively. With regard to their values presented in **Table 4**, it implies that the measurement scale reached a satisfactory convergent validity in this study.

In comparison to the convergent validity, the discriminant validity emphasizes the uniqueness of each construct from its other counterparts. The good discriminant validity, in general, necessitates a higher value of its square root of AVE of one construct compared with its correlations with other constructs. The descriptive statistics in **Table 5** illustrates the good discriminant validity among constructs in this study.

Hypothesis Testing

To complete the assessment of the measurement model, a structural equation modeling (SEM) technique was applied to test the proposed hypotheses in the research model. From various indexes, there was an observed satisfactory fit of the research model to the data (CMIN = 184.231, df = 81, CMIN/df = 2.274, GFI = 0.906, RMSEA = 0.073, CFI = 0.971, and NFI = 0.951). **Table 6** summarizes the results of hypothesis testing from SEM.

Overall, the standardized value from path analysis suggested that all the proposed hypotheses in the research model were supported by regression results. In light of Hypothesis 1, from data it is suggested that the CSR engagement of DiDi on WeChat significantly affected C–C identification ($\beta = 0.745$, $p < 0.01$). Meanwhile, the standardized result of path analysis also showed a positive correlation between C–C identification and behavioral intention of customers (H2a: $\beta = 0.383$, $p < 0.001$, H2b: $\beta = 0.812$, $p < 0.01$, H2c: $\beta = 0.392$, $p < 0.01$). Finally, the results of SEM also supported that brand loyalty had a positive impact on the purchase intention of customers (H3a: $\beta = 0.588$, $p < 0.01$) and eWOM (H3b: $\beta = 0.425$, $p < 0.01$).

TABLE 4 | Descriptive statistics of convergent validity.

Constructs	Item	Standardized factor loading	SE	CR	AVE
CSR engagement	CSR1	0.919***	-	0.93	0.817
	CSR2	0.931***	0.045		
	CSR3	0.862***	0.05		
CCI	CCI1	0.928***	-	0.944	0.812
	CCI2	0.959***	0.036		
	CCI3	0.904***	0.043		
	CCI4	0.782***	0.046		
BL	BL1	0.906***	-	0.89	0.729
	BL2	0.768***	0.059		
	BL3	0.89***	0.048		
PI	PI1	0.88***	-	0.834	0.718
	PI2	0.802***	0.052		
eWOM	eWOM1	0.871***	-	0.919	0.792
	eWOM2	0.926***	0.056		
	eWOM3	0.868***	0.056		

SE, standard error. ***$p < 0.01$.

TABLE 5 | Descriptive statistics of the discriminant validity.

	CSR engagement	CCI	BL	PI	eWOM
CSR engagement	0.904				
CCI	0.712	0.901			
BL	0.66	0.775	0.854		
PI	0.661	0.765	0.796	0.847	
eWOM	0.629	0.707	0.695	0.632	0.89

TABLE 6 | Results of hypotheses testing.

Hypothesized path	Standardized path coefficient (β)	t-value	SE	Supported
H1a CSR engagement—CCI	0.760**	14.089	0.068	Yes
H2a CCI—PI	0.383**	4.834	0.056	Yes
H2b CCI—BL	0.812**	15.358	0.046	Yes
H2c CCI—eWOM	0.397**	4.367	0.076	Yes
H3a BL—PI	0.588**	7.099	0.068	Yes
H3b BL—eWOM	0.425**	4.565	0.090	Yes

**$p < 0.01$.

TABLE 7 | Results of mediating effect between CSR engagement and behavioral intention.

	BL		PI		e-WOM		CCI
	M1	M2	M3	M4	M5	M6	M7
Independent variable (CSR engagement)	0.710** (13.534)	0.249** (4.243)	0.362** (13.062)	0.132** (4.133)	0.670** (11.989)	0.273** (4.005)	1.095** (14.766)
Mediating variable (CCI)		0.421** (11.337)		0.210** (10.412)		0.362** (8.394)	
Control variable							
Gender	−0.119 (−0.316)	−0.236 (−0.778)	0.045 (0.225)	−0.014 (−0.083)	−0.342 (−0.853)	−0.443 (−1.256)	0.278 (0.522)
Age	−0.027 (−0.127)	0.267 (1.567)	−0.051 (−0.462)	0.096 (1.031)	−0.355 (−1.593)	−0.102 (−0.516)	−0.697* (−2.357)
Occupation	0.232 (1.807)	0.170 (1.639)	0.072 (1.054)	0.040 (0.717)	−0.199 (−1.452)	−0.252* (−2.096)	0.148 (0.816)
City	−0.040 (−0.289)	−0.072 (−0.640)	0.049 (0.659)	0.033 (0.536)	−0.230 (−1.548)	−0.257 (−1.970)	0.075 (0.381)
R^2	0.446	0.642	0.442	0.618	0.429	0.561	0.521
Adjusted R^2	0.434	0.633	0.43	0.609	0.417	0.55	0.51
F	$F_{(5,235)} = 37.855$, $p = 0.000$	$F_{(6,234)} = 70.084$, $p = 0.000$	$F_{(5,235)} = 37.170$, $p = 0.000$	$F_{(6,234)} = 63.202$, $p = 0.000$	$F_{(5,235)} = 35.339$, $p = 0.000$	$F_{(6,234)} = 49.898$, $p = 0.000$	$F_{(5,235)} = 51.057$, $p = 0.000$

$^{**}p < 0.01$, $^{*}p < 0.05$; Figures in parentheses are SEs.

In addition to the direct effect examined through path analysis, the casual steps approach and Sobel test were adopted to assess the mediating effect of C–C identification between CSR engagement and three behavioral intention (H4a–H4c). **Table 7** shows the results of the evaluation of the hypothesized mediating effects with the demographic information being set as controllable variables. In view of the H4a, first a regression analysis was conducted where CSR engagement and brand loyalty were set as the independent variable and dependent variable, respectively, indicating a significant positive effect of CSR engagement on brand loyalty (Model 1, $\beta = 0.710, p < 0.01$). Second, the regression coefficient from the independent variable (CSR engagement) and the mediator (C–C identification) showed a significant relationship in Model 7 ($\beta = 1.095$, $p < 0.01$). Third, there was also an observed significant positive effect when CSR and C–C identification were processed as independent variables simultaneously and brand loyalty as dependent variable (Model 1, $\beta = 0.249$, 0.421, $p < 0.01$). Considering that the regression coefficient of CSR engagement and brand loyalty (0.249) from the third step was smaller than the one (0.710) from the first step, it could be concluded that there was a partial mediating effect of C–C identification between CSR engagement and brand loyalty. Therefore, H4a was supported through the above regression analysis. The same approach was also used to assess H4b and H4c, whose regression results both indicated the partial mediating effects of C–C identification between CSR engagement and purchase intention and eWOM, respectively.

DISCUSSION AND CONCLUSIONS

With the purpose to fill in the identified research gaps, this study was an endeavor to explore the effect of CSR engagement in social media during and after the COVID-19 pandemic with psychological insights. More precisely, with particular attention to the shared brands, this study is concerned with the psychological mechanism of whether and how the behavioral intention of customers could be influenced by their CSR engagement in social media during the damaging coronavirus pandemic.

Through the investigation of the perception of customers on CSR engagement of DiDi (a Chinese representative shared brand) on WeChat, it was found that DiDi engaging in such initiatives during the COVID-19 could bring them positive effects while they are experiencing a market downturn caused by this crisis. This result, therefore, further led evidence to the claims emphasizing the significant role of CSR engagement in a critical period and the great potential of social media for such organizational activities (She and Michelon, 2019; Puriwat and Tripopsakul, 2021). More precisely, with empirical statistics, this study first found that companies with CSR engagement in fact satisfied the self-need of customers, which, in turn, could positively strengthen their identification of customers with themselves even in times of crisis (Bhattacharya and Sen, 2003; Lii and Lee, 2012). Moreover, social media could accelerate the social identification process in that the engagement had been intensified with more accessibility (Fatma et al., 2020). Second, this study also evidenced the partial mediating role of C–C identification between CSR engagement and behavioral intention of customers (Bhattacharya and Sen, 2003; Martínez and Rodríguez del Bosque, 2013). Taking advantage of social media, companies with enhanced C–C identification in fact could optimize brand loyalty, purchase intention, and positive eWOM of their customers. To the best of our knowledge, this study offers an explorative insight into the psychological process concerning the effect of CSR engagement of the shared brands on the behavioral intention of customers during the COVID-19, which is a relatively under-researched topic in the CSR literature.

With regard to the theoretical implication, the findings of this study in fact add to the CSR study from three perspectives. First, this study expanded the discussion of CSR performed

by new industries through emerging social platforms (the CSR engagement of DiDi on WeChat). From a review of the study, it indicates that prior studies have typically confined to the CSR practices by traditional industries in traditional messages channels (Brammer et al., 2007; She and Michelon, 2019; Puriwat and Tripopsakul, 2021). How social media interplay with CSR initiatives of emerging industries is relatively an unresearched area (Hu et al., 2019). Second, this study offers further evidence of the necessity of CSR engagement, especially in such a critical period as the COVID-19 pandemic. To comprehensively understand its impact, this study typically investigated CSR practices happening in a critical period. Through empirical statistics, it confirmed the critical role of CSR engagement for business in relation to the behavioral intention of customers while confronted by such a negative external environment as the pandemic COVID-19 (Puriwat and Tripopsakul, 2021). Third, based on the social identity theory, this study dissected the psychological mechanism underlying the effects of CSR engagement on the behavioral intention of customers. Most notably, it is suggested that C–C identification in fact plays a mediating role between CSR engagement and behavioral intention of customers, which corresponds to the claims of Han, H. et al. (2020) and He and Li (2011). Overall, of theoretical concern, this study based on an interdisciplinary perspective in nature is a stepping stone for further studies of CSR engagement occurring in social media.

From a practical standpoint, the findings of this study yield some managerial implications for business practitioners. Regardless of the sudden decrease in the available capitals for business operation during the COVID-19, managers are still suggested to invest in their CSR engagement that in fact can help them win over more economic benefits in the competitive market. In light of the mediating role of C–C identification, it is indicated that companies with CSR engagement are more likely to stimulate their identification, which, in turn, could effectively influence the behavioral intention of customers. During the coronavirus pandemic, there is an observed change happening on the communicative landscape where people are increasingly involved themselves in social media. In this way, managers should utilize social media as a promotional tool that has a great potential to enhance the behavioral intention of customers, thereby increasing their economic returns.

Several limitations of this study also offer directions for future studies. This study has typically focused on the CSR engagement of DiDi happening on WeChat, which restricts the generalizability of the results. Further studies should incorporate other social media platforms and more shared brands for a comprehensive understanding. Second, in response to the real-time external environment, the researcher examined the CSR engagement while the world is experiencing the damaging coronavirus. A longitudinal study is hence suggested to be necessary for making a comparative analysis of the CSR engagement in different periods.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary files, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

YW and WZ together developed the present research idea. YW was responsible for the data collection, data analysis, and the first draft of the manuscript. WZ acted as an instructor throughout the work and contributed to improve the manuscript. All authors contributed to the article and approved the submitted version.

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The Impact of the Coronavirus Disease 2019 Pandemic on Investor Sentiment—Evidence From A-Share Listed Companies in China

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In a DID model, this study examines the impact of the coronavirus disease 2019 (COVID-19) pandemic on the investor sentiment in the financial market of China using monthly panel data on newly listed Chinese companies between October 2019 and June 2020. The outbreak of the pandemic is shown to exert a significant negative impact on investor sentiment. A future industry heterogeneity analysis shows that the pandemic has driven up investor sentiment in the pharmaceutical sector while having a significantly negative impact on non-pharmaceutical sectors. The pandemic is shown to have a negative impact on the private sector and foreign-invested sector in China while a significantly positive impact on the state-owned sector. This study contributes to the existing literature on the investigation of how significant the impact of public health emergencies on investor sentiment is.

Keywords: investor sentiment, COVID-19 pandemic, difference-in-differences model, financial market, A-share listed companies

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INTRODUCTION

The 2020 outbreak of the coronavirus disease 2019 (COVID-19) pandemic, a global public health crisis, has hit the Chinese economy and the world economy hard. According to the WHO statistics, the pandemic has swept across more than 200 countries, causing a total of 83 million people worldwide with confirmed infection while killing over 1.8 million people.

The impact of the COVID-19 pandemic on the financial market of China is substantial. Shanghai Composite dipped by around 7.7%, a 5-year single-day low. At the same time, CSI Aggregate Bond rose by about 0.62%, a second decade-high. The forex market and currency market are also hit to various extents. Investor sentiment can reflect the general market trend and market vitality (Yu et al., 2020). Then, does the pandemic exert an impact on investor sentiment? If the answer is yes, then how should we measure the impact? Does investor sentiment vary across firm types and industries? How should China respond to the change? The answers to the above questions may help policymakers take measures to stabilize the financial market and formulate solutions to financial market turmoil. However, there is a minimal existing research literature on the impact of major public health events on investor sentiment. This study is intended to contribute to the understanding of this issue by looking at the impact of the COVID-19 pandemic on investor sentiment in the financial market of China.

This study uses a difference-in-difference (DID) model to study the impact of the COVID-19 pandemic on investor sentiment in the financial market of China. The improved turnover rate is used to measure the investor sentiment on individual stocks. This study focuses on the following variables: trading volume, free float equity, market value, financial indicators, etc., trying to study the impact of major economic shocks on investor sentiment in theA-share market of China. This study has important policy value for economic policies in responding to major public health incidents, stabilizing the A-share market, and safeguarding economic development in China.

The rest of the study is roughly organized as follows. The "Literature review" section reviews the previous studies. The "Model, variable selection, and data sources" section explains the model, variable, and data. The "Empirical analysis and findings" section provides the details of the empirical analyses. The "Conclusion" section concludes.

LITERATURE REVIEW

Investor Sentiment Literature

Behavioral finance theories imply a considerable impact of the psychological factors of the investor on the financial market. Existing approaches to measuring investor sentiment include direct proxy, indirect proxy, and text mining. In direct proxy, Brown and Cliff (2005) used a questionnaire survey to understand the outlooks of the investor on market trends. Kenneth and Meir (2000) categorized the investors into three subcategories, namely, large investors, medium-size investors, and small investors. Jiang et al. (2021) regarded the Baidu index as an indicator of investor sentiment and believed that investor sentiment is usually affected by the information provided by the Baidu search engine, which may cause stock prices to fluctuate. As single-indicator-based measurement may be subjected to bias, some scholars constructed an index system to measure investor sentiment. Baker and Wurgler (2006) and Yi and Mao (2009) cited six independent proxy indices to construct the investor sentiment composite index based on principal component analysis.

Individual investor sentiment is measured primarily based on big data analysis methods as data analysis and text mining. Baker and Stein (2004) pointed out that liquidity measured by turnover rate can be an indicator of investor sentiment. Das and Chen (2008) proposed a method of gauging the sentiment of small investors from a web-based message board by comparing the optimistic and pessimistic views. Balke et al. (2017) and Zhang (2019) provided methods to measure sentiment based on surveys and government policies. Yang et al. (2016) used big data mining to measure the investor sentiment index using big data mining from around 900,000 posts issued by listed companies on the website of Eastmoney Securities. Fang et al. (2020) used the data from Baidu, the leading search engine in China, to construct an indicator of investor sentiment for forecasting of returns of the Chinese stock market.

The existing literature also investigates how investor sentiment exerts an impact on the stock market and what factors drive investor sentiment (Delong et al., 1990; Fisher and Statman, 2000). In studying the correlation of asset pricing with investor sentiment, Brown and Cliff (2005) suggested the latter indicator has an impact on the former, i.e., investor sentiment change leads to stock fluctuation. Based on the statistics of the Chinese stock market, Xie and Tang (2021) concluded that positive investor sentiment can drive up the yield rate to some degree and this impact can last for around a year. Gozgor et al. (2019) pointed out that economic policy uncertainty affects gold returns, which in turn affects investor behavior and investor sentiment. During periods of high economic policy uncertainty, especially during the early 2020s and the COVID-19 pandemic, economic policy uncertainty exerts a considerable impact on the financial stock market and affects investment returns (Wu et al., 2021). Li et al. (2017) and Zhang et al. (2021) constructed investment sentiment indicators and analyzed the impact of external shocks on the sentiment of Chinese investors.

Literature on the Impacts of Major Public Health Events

Since the twenty-first century, there have been five grave pandemics of infectious diseases defined by WHO as major public health events on a global scale or higher. Many scholars have assessed the impact of these events on the growth of the economy as a whole (Brainerd and Sieglar, 2003; Wu, 2003; Hanna and Huang, 2006). Barro et al. (2020), based on the death toll during the 1918–1929 influenza pandemic and the death toll in World War I, estimated the death toll of the COVID-19 pandemic and its economic impact, finding the severely impacted countries registered a 6% drop and an 8% drop in GDP and consumption, respectively. The outbreak of the COVID-19 pandemic interrupts the product supply chain, and the global economy is in face of a recession (Shang et al., 2021). Brem et al. (2021) discussed 10 technologies that play a major role in the COVID-19 crisis and found that technological innovation has a key role in response to the epidemic and subsequent economic recovery. Cai et al. (2021) analyzed the impact of the explosive pandemic on the labor market of China. The results showed that under the impact of the pandemic, overall employment assumed a "V"-shaped trend. Based on the monthly panel data of Chinese provinces and cities, Zhang and Zhu (2021) used DID model to analyze the impact of the pandemic on various industries and concluded that the pandemic has a significant negative impact on international trade and the road freight industry.

External shocks tend to exert a significant impact on the financial stock market (Baker et al., 2020; Zhao et al., 2021). Chen (2020) used the event analysis method to analyze the impact of the pandemic on the stock market of China, and the results showed that the return rate of the market at large had dropped significantly during the pandemic and impacted on different types of firms to varying degrees. Wang et al. (2020) used the panel VAR model and dynamic econometric model to evaluate the impact of the COVID-19 on stock price fluctuation and concluded that fear and anxiety from the pandemic may drive investors to sell stocks and to cause price fluctuation. Sun et al. (2021) studied the impact of investor sentiment during the pandemic on pharmaceutical stock trading in mainland China,

Hong Kong, South Korea, Japan, and the United States, and the results showed that ERAs had a significant positive effect on pharmaceutical investment portfolios in these markets.

The related investigations focus on investor sentiment mainly from the perspective of investor attention metrics and the impact of investor sentiment on the financial stock markets; major public health events are studied based on the impact on the economy and the financial market. Few studies employ investor sentiment as an explained variable to study the impact of the pandemic as an external shock on investor sentiment. Our study is intended to make three contributions to the existing literature. First, we introduced the listed firms on the A-share stock market of China as the research object and analyzed the impact of the pandemic on investor sentiment at the firm level. Second, the authors introduced new research methods by considering the pandemic as a quasi-natural experiment and building a DID model intended to assess the impact of the pandemic on investor sentiment. Meanwhile, the propensity score matching-difference-in-difference (PSM-DID) method and the placebo-controlled test were used to conduct a series of robustness tests. Third, the heterogeneity analysis was applied to the model being built to illustrate the impact of the pandemic on investor sentiment based on the firm type and industry differences.

MODEL, VARIABLE SELECTION, AND DATA SOURCES

Model Building

In January 2020, the pandemic first broke out in Wuhan, China and then quickly spread to other cities. However, the Chinese government decisively adopted strict lockdown measures, which resulted in effective control of the spread of the virus. To analyze the impact of the pandemic on domestic investor sentiment, we took the 2020 outbreak as the start time, regarded the pandemic as an external shock, and studied investor sentiment based on a DID model. This model is widely used to evaluate the effects of policies in different pilot regions. Similar to the implementation of policies in different pilot regions, the outbreak of the COVID-19 pandemic in different regions can also be regarded as a quasi-natural experiment.

We considered those Chinese provinces with a cumulative number of confirmed infection cases not <1,000 (Zhang and Zhu, 2021). Listed firms registered after December 2019 in Hubei, listed firms registered after February 2020 in Guangdong, Henan, and Zhejiang, and listed firms registered after March 2020 in Hunan are used as the treatment groups, while listed firms listed in other provinces served as the control groups. The time series of provinces with a cumulative number of confirmed cases over 1,000 are shown in **Table 1**.

The model is as follows:

$$sent_{it} = \alpha_0 + \beta_1 post_{it} \times treat_{it} + \gamma X_{it} + v_i + \mu_t + \varepsilon_{it}. \quad (1)$$

The explained variable *sent* represents investor sentiment on the individual listed firm of i at a specific time (t). All the listed firms in the sample fall into four groups. If $post_{it} = 1$ and $treat_{it} = 1$, the firm falls into the post-pandemic treatment group; if $post_{it} = 0$ and $treat_{it} = 1$, the firm falls into the pre-pandemic treatment group; if $post_{it} = 1$ and $treat_{it} = 0$, the firm falls into the post-pandemic control group; and if $post_{it} = 0$ and $treat_{it} = 0$, the firm falls into the pre-pandemic control group. In this study, the core explanatory variable was $post_{it} \times treat_{it}$, and β_1 measures the impact of the pandemic on investor sentiment. If $\beta_1 < 0$, the pandemic is shown to reduce the turnover rate and make the investors pessimistic; if $\beta_1 > 0$, the pandemic on its full-scale tends to increase the turnover rate. Besides, X_{it} is a series of control variables, v_i is the individual fixed effects, μ_t is the time fixed effects, and ε_{it} is the random error term.

TABLE 1 | The time series of confirmed cases with a cumulative number of over 1,000 in the provinces.

Province	Number of confirmed cases in province	Number of confirmed cases nationwide	Time
Hubei	7,153	11,791	2020/01
Guangdong	1,349	79,824	2020/02
Henan	1,272	79,824	2020/02
Zhejiang	1,205	79,824	2020/02
Hunan	1,018	81,554	2020/03

Variable Selection

sentiment, used in this study as an explained variable, refers to theoretically inexplicable factors that drive investors make stock market forecasts based on macroeconomics and company data. It can be seen as a specific risk in connection with capital market development and reflects the market forecasts and confidence of investors in their own investment strategy. The turnover rate is an indicator normally used in measuring investor sentiment on an individual stock and is calculated generally as trading volume divided by total equity. However, a vast number of the stocks on the A-share stock market are traded off the exchange. In this study, we improved the approach to measuring investor sentiment on individual stocks. We used turnover divided by free float as the proxy variable for investor sentiment. We do not include (i) the free floats of shareholders who held more than 5% of the outstanding shares of the firm and (ii) the free floats of shareholders who held <5% of the outstanding shares of the firm and whose associated shareholders held 5% of the outstanding shares of the firm. According to the studies of Wang and Wang (2014), Larrain and Urzúa (2013), and Tian et al. (2020), we selected seven control variables, namely, firm size (*size*), independent director percentage (*Indep*), firm age (*lnage*), percentage of holdings of top shareholder (*top1*), market value and book value (*mvba*), enterprise accounting performance (*epa*), and financial leverage (*lev*). **Table 2** shows the definitions of the control variables in detail.

Data Source

We used monthly panel data of the firms listed on the A-share stock market of China dated from October 2019 to June 2020 as the initial samples. Since the New Year Holiday

TABLE 2 | The description and definitions of main variables.

Variable category	Variable name	Meaning	Calculation method
Explained variable	Sent	Investor sentiment	Trading volume/free float equity
Explanatory variables	Post	Time of the outbreak	The time when the epidemic occurred, after the new crown pneumonia epidemic event, it was 1, and before it was 0
	Treat	Epidemic shock	For the listed companies in the treatment group, the value of Treat is 1, and the value of other companies is 0
Control variable	Size	Enterprise size	Ln(Enterprise total assets)
	Indep	Proportion of independent directors	Total number of independent directors/total number of board of directors
	Lnage	Business age	Ln(Years of listing)
	Top1	Shareholding ratio of the company's largest shareholder	The largest shareholder's shareholding ratio
	Mvba	Book value	Enterprise market value/total assets
	Epa	Corporate Accounting Performance	Corporate return on equity
	Lev	Corporate financial leverage	Total liabilities/total assets

TABLE 3 | The descriptive analysis.

Variable	*N*	Mean	SD	Min	Max
Sent	16,983	0.610	0.663	0.005	8.269
Indep	16,983	0.380	0.056	0.250	0.800
Epa	16,983	0.018	0.222	−9.179	1.978
Size	16983	22.260	1.273	18.13	29.710
Lev	16,983	0.410	0.194	0.008	0.978
Top1	16,983	0.316	0.140	0.030	0.882
Mvba	16,983	0.197	0.213	0.004	3.343
Lnage	16,983	2.916	0.296	0	4.111

Source: CSMAR database.

and the Chinese New Year fell on January 2020, this study eliminated the possible impact of such factors on the A-share stock market by excluding the data on January 2020. In addition, considering the importance of accuracy and robustness of the research findings, we processed the initial samples by excluding real property developers, financial institutions, ST stocks, *ST stocks, samples with data missing, and samples traded for <15 days per month. Finally, 16,983 observation values were returned. All the statistics are sourced from the GTA CSMAR database.

EMPIRICAL ANALYSIS AND FINDINGS

Descriptive Statistics-Based Analysis

Table 3 shows the descriptive statistics of our selected variables.

Basic Regression Analysis

First, we made a DID estimation of equation (1). The basic regression results are shown in **Table 4**. The first column showed the estimates of the time fixed effect and the individual fixed effect. The explanatory variable *post* × *treat* equaled to −0.0552 and was significant at the 1% level, indicating that the outbreak of the pandemic drove down the turnover rates on the A-share stock market and led to pessimistic investor sentiment. The second column, including control variables, shows significant results, which indicate that in those provinces hit harder by the pandemic, the listed firms are subject to a more negative shock on investor sentiment. This was due to waning confidence and an overall pessimistic outlook on the financial market.

ROBUSTNESS CHECKS

Parallel Trend Test

An important assumption for the DID estimation is that the treatment groups and the control groups are assumed to have the same trend without an obvious difference. This study shows that the parallel trend test results are in a 95% CI. As shown in **Figure 1**, the treatment groups and the control groups had no obvious difference before the pandemic broke out. In early February 2020 when the pandemic broke out, the panic on the A-share stock market of China caused the investors to sell off the holdings in large quantities, and therefore, there was a decline in investor sentiment. After the outbreak, there was a significantly negative, aggravating impact on investor sentiment, which is an important cause for the obvious difference in investor

sentiment between the treatment groups and the control groups. In April 2020, the impact on investor sentiment rebounded to some degree thanks to government policy support and effective control measures.

TABLE 4 | Benchmark model regression results.

Variables	(1)	(2)
	Sent	Sent
Post × treat	−0.0552***	−0.0262**
	(0.014)	(0.012)
Indep		0.2613
		(0.164)
Epa		0.0199
		(0.018)
Size		−0.1112***
		(0.008)
Lev		0.3592***
		(0.054)
Top1		−0.1272*
		(0.066)
Mvba		0.9582***
		(0.038)
Lnage		−0.2402***
		(0.030)
Constant	0.4250***	3.2275***
	(0.015)	(0.200)
Individual fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Observations	16,983	16,983
Within_R2	0.1302	0.1686
Between_R2	0.0059	0.1911
Overall_R2	0.0535	0.1552

****, **, and * denote significance at 1, 5, and 10%, respectively. The SEs are in parentheses.*

Heterogeneity Analysis

The impact of the pandemic on investor sentiment may vary with the characteristics of the listed firms; therefore, the impact of the pandemic is analyzed from the perspective of the sector and firm ownership.

The impact of the pandemic on investor sentiment also varies across industries, i.e., the pharmaceutical or non-pharmaceutical sector. This study divided the listed firms on the A-share stock market into the pharmaceutical sector and the non-pharmaceutical sector. As shown in **Table 5**, when it comes to the pharmaceutical sector, the outbreak of the pandemic had a significantly positive impact on investor sentiment, but when it comes to the non-pharmaceutical sector, there was a significantly negative impact. This result makes sense as the pandemic leads to an upsurge in demand for medical supplies. The government invested more in the pharmaceutical sector, and the investors also expect the sector to be promising.

This study classified the firms traded on the A-share stock market based on firm ownership. Firms involving a state-owned stake were categorized as a state-owned firm, firms involving a privately owned stake were categorized as a privately owned firm, and firms involving a foreign-owned stake were categorized as a foreign-owned firm. In **Table 6**, columns 1–3 show the regression results of the firms of different ownerships. For the privately owned and foreign-owned firms, investor sentiment has a negative coefficient. In contrast, for the state-owned firms, the investor sentiment coefficient was significantly positive at a 1% level. For the foreign-owned firm, the negative impact of the pandemic on investor sentiment makes sense mainly because the pandemic is an international public health event. The pandemic

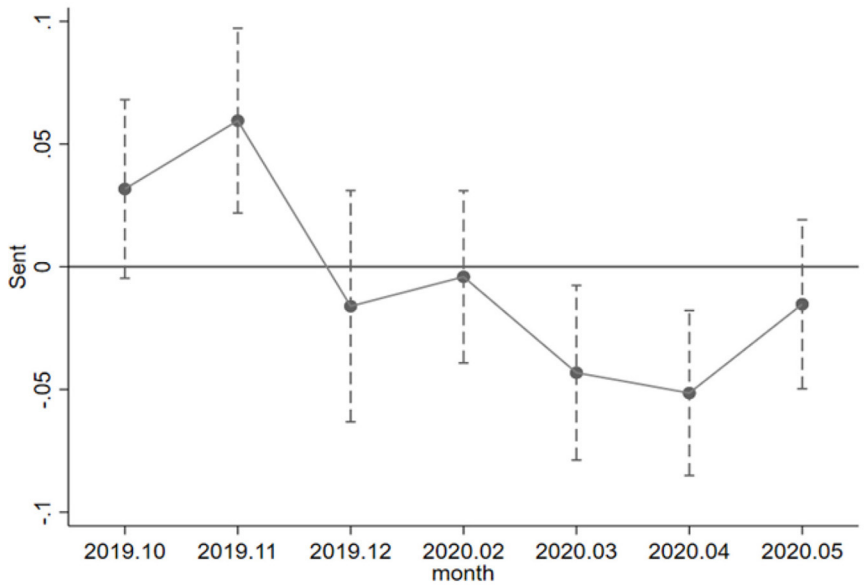

FIGURE 1 | Parallel trend test.

TABLE 5 | Regression results (the pharmaceutical sector vs. the non-pharmaceutical sector).

Variables	(1)	(2)
	Pharmaceutical industry	Non-pharmaceutical industry
Post × treat	0.1155***	−0.0351***
	(0.043)	(0.013)
Indep	−0.3468	0.3007*
	(0.543)	(0.170)
Epa	0.0521	0.0166
	(0.059)	(0.018)
Size	−0.1198***	−0.1057***
	(0.029)	(0.009)
Lev	0.3681**	0.3545***
	(0.174)	(0.056)
Top1	−0.0379	−0.1416**
	(0.237)	(0.068)
Mvba	0.2062**	1.1044***
	(0.087)	(0.042)
Lnage	−0.0479	−0.2308***
	(0.107)	(0.032)
Constant	3.0777***	3.0568***
	(0.726)	(0.208)
Individual fixed effects	Yes	Yes
Time fixed effects	Yes	Yes
Observations	1,533	15,450
Within_R2	0.2099	0.1700
Between_R2	0.0885	0.2116
Overall_R2	0.1440	0.1702

****, **, and * denote significance at 1, 5, and 10%, respectively. The SEs are in parentheses.*

TABLE 6 | Ownership regression results (state-owned firm vs. privately owned firm vs. foreign-owned firm).

Variables	(1)	(2)	(3)
	State-owned firm	Privately owned firms	Foreign-owned firm
Post × treat	0.1137***	−0.0431***	−0.0370
	(0.015)	(0.016)	(0.046)
Indep	0.1316	0.2105	0.0294
	(0.162)	(0.241)	(0.623)
Epa	−0.0640	0.0188	0.0081
	(0.054)	(0.025)	(0.034)
Size	−0.0543***	−0.1287***	−0.0861***
	(0.008)	(0.014)	(0.032)
Lev	0.3196***	0.4374***	0.1071
	(0.061)	(0.075)	(0.193)
Top1	−0.2607***	−0.0322	−0.0540
	(0.070)	(0.098)	(0.214)
Mvba	1.1059***	1.0299***	0.5097***
	(0.081)	(0.050)	(0.097)
Lnage	−0.0270	−0.1973***	−0.6222***
	(0.035)	(0.043)	(0.110)
Constant	1.4236***	3.4446***	4.0787***
	(0.219)	(0.325)	(0.786)
Individual fixed effects	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes
Observations	4,319	11,070	1,594
Within_R2	0.0690	0.1879	0.1069
Between_R2	0.2017	0.1231	0.2001
Overall_R2	0.1413	0.1227	0.1328

****, **, and * denote significance at 1, 5, and 10%, respectively. The SEs are in parentheses.*

began to sweep across China in early 2020 and from March 2020, transmitted on a large scale to other countries. The pandemic worsened quickly and countries worldwide took emergency measures in response. Hence, the world economy faced a recession, international demand shrank by a large margin, and import and export markets of China suffered heavily. Therefore, the investors had a generally prudential, or pessimistic, attitude to invest in these firms. Privately owned firms were generally weak in risk resistance, so they were the most impacted. In quite a few provinces, the SMEs went broke under heavy impact. Compared with the privately owned firm and the foreign-owned firm, the state-owned firm was less hit by the pandemic because of government backing as an advantage. When the panic about the pandemic enshrouded the whole market, the market investors chose to buy in more stocks of the state-owned firm, hence its high turnover rate. The investors were, in themselves, optimistic about the state-owned firm. Therefore, the ability of the privately owned firm and the foreign-owned firm to adapt to external shocks should be improved. When a major crisis breaks out, the government should increase its support for such enterprises. The enterprises themselves should increase investment in Science and Technology, promote technological innovation, improve their own anti-risk capabilities, and increase investor confidence in them.

Placebo-Controlled Test

To test if investor sentiment is driven by other unobservable factors, a certain number of groups were sampled on a random basis for the purpose of the robustness test. In this study, 500 random samplings were conducted and for each sampling, some of the provinces sampled served as the treatment groups and randomly sampled months between October 2019 and April 2020 served as the time of the outbreak. Our analysis gives the estimated coefficient of investor sentiment as a dependent variable. Based on the basic regression of statistics as shown in **Table 4**, the estimated coefficient with investor sentiment as the dependent variable was −0.0552, obviously different from the coefficient returned by the placebo-controlled test as shown in **Figure 2**. Therefore, the existence of other unobservable factors on investor sentiment was insignificant.

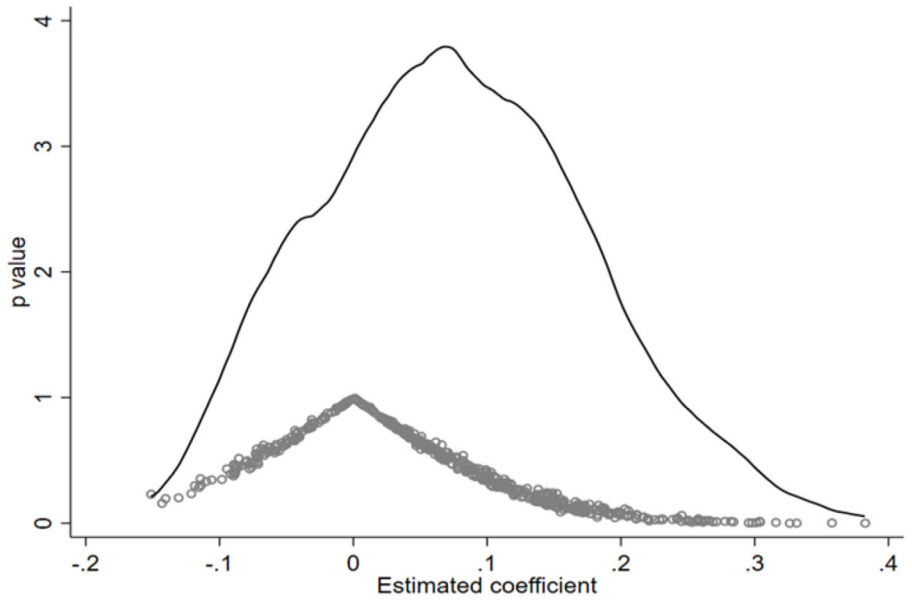

FIGURE 2 | Placebo-controlled test.

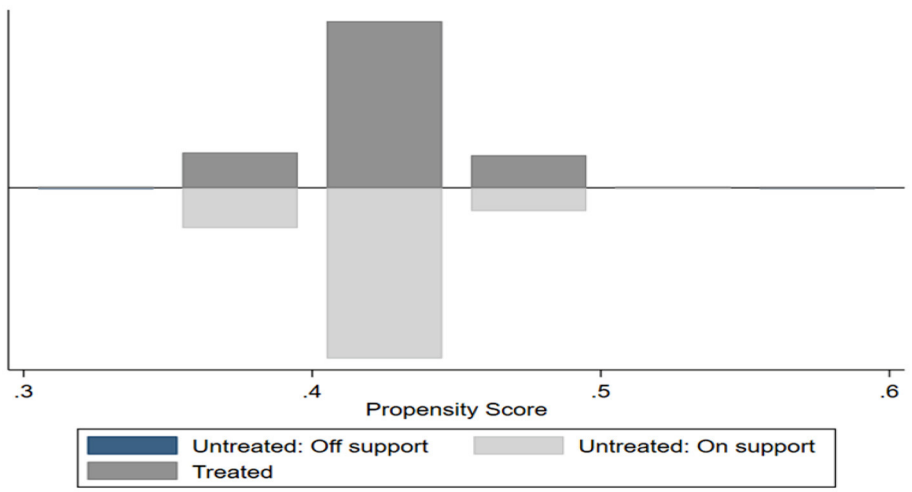

FIGURE 3 | Overlapping assumption test.

PSM-DID Test

This study conducted a PSM analysis of investor sentiment to reduce the selection bias associated with sampling. The various matching variables, i.e., *lnage*, *size*, the debt-to-asset ratio, and *mvba*, were used as a basis for PSM to select appropriate control groups, and the matched samples underwent DID estimation. An important assumption for PSM is the fulfillment of overlapping one. If both treatment groups and control groups have high propensity scores, it points to a high degree of overlap and the effectiveness of the PSM model, and the reverse is true. **Figure 3** shows the results of the overlapping assumption test. There was an overlap of the treatment groups with the control groups, i.e., the overlapping assumption was fulfilled. Also, addressing selection bias with PSM has to fulfill the balance assumption, i.e., except for investor sentiment, there should be no significant difference between the treatment groups and the control groups. It is generally supposed that a post-matching SD <20% points to a good matching effect. **Table 7** shows the balancing test results, which shows that the post-matching SDs of the sample variables dropped below 20%, indicative of the fulfillment of the balancing assumption.

With the above overlapping assumption test and balancing test, a PSM-robustness test was conducted. 1:3 nearest neighbor matching, radius matching, and kernel matching

TABLE 7 | Balancing assumption test.

Covariate	Unmatched U/matched M	Treatment group mean	Control group mean	%bias	*t* value	*p* value
Lnage	U	2.9098	2.9203	−3.5	−2.29	0.022
	M	2.9098	2.9085	0.4	0.26	0.795
Size	U	22.203	22.293	−7.1	−4.59	0.000
	M	22.203	22.177	1.9	1.17	0.241
Lev	U	0.41154	0.40863	1.5	0.97	0.332
	M	0.41154	0.4084	1.6	0.98	0.327
Mvba	U	0.20247	0.1922	4.8	3.10	0.002
	M	0.20247	0.19979	1.3	0.75	0.455

TABLE 8 | Propensity score matching test (nearest neighbor matching vs. radius matching vs. kernel matching).

Variables	(1)	(2)	(3)	(4)	(5)	(6)
	Nearest neighbor matching	Nearest neighbor matching	Radius matching	Radius matching	Kernel matching	Kernel matching
Post × treat	−0.0556***	−0.0268**	−0.0556***	−0.0270**	−0.0552***	−0.0262**
	(0.014)	(0.012)	(0.014)	(0.012)	(0.014)	(0.012)
Indep		0.2513		0.2591		0.2613
		(0.164)		(0.164)		(0.164)
Epa		0.0211		0.0566**		0.0199
		(0.018)		(0.024)		(0.018)
Size		−0.1123***		−0.1118***		−0.1112***
		(0.008)		(0.008)		(0.008)
Lev		0.3700***		0.3666***		0.3592***
		(0.054)		(0.054)		(0.054)
Top1		−0.1330**		−0.1295**		−0.1272*
		(0.066)		(0.066)		(0.066)
Mvba		0.9709***		0.9605***		0.9582***
		(0.038)		(0.038)		(0.038)
Lnage		−0.2408***		−0.2401***		−0.2402***
		(0.030)		(0.030)		(0.030)
Constant	0.4250***	3.2526***	0.4251***	3.2386***	0.4250***	3.2275***
	(0.015)	(0.202)	(0.015)	(0.200)	(0.015)	(0.200)
Individual fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,970	16,970	16,977	16,977	16,983	16,983
Within_R2	0.1302	0.1690	0.1303	0.1690	0.1302	0.1686
Between_R2	0.0057	0.1910	0.0059	0.1913	0.0059	0.1911
Overall_R2	0.0534	0.1556	0.0535	0.1557	0.0535	0.1552

****, **, and * denote significance at 1, 5, and 10%, respectively. The SEs are in parentheses.*

were implemented. **Table 8** shows the relative regression results, which shows that the coefficient of the variable post × treat remained significantly at a 1% level.

CONCLUSION

To evaluate how and to what extent the COVID-19 pandemic exerts an impact on investor sentiment, this study conducted research on the performance of the A-share stock market of China during the pandemic by doing a quasi-experiment based on the pandemic. Besides, the DID model was used to investigate the impact of the arrived at three conclusions. First, the pandemic drove down the turnover rate on the A-stock market and made the investors pessimistic, so those currently without holdings did not involve themselves in market trading. Second, the pandemic impacted negatively on investor sentiment and brought it down significantly when it comes to the privately

owned firms and the foreign-owned firms; in contrast, the state-owned firms attracted many individual investors on the strength of their unique advantages. Third, the outbreak of the pandemic drew broad attention to the pharmaceutical industry from the government and people, so it boosted up investor sentiment in the pharmaceutical industry while having a significantly negative impact on the non-pharmaceutical industry.

In general, considering the pandemic as an external shock that exerts a substantial impact on investor sentiment, the Chinese government and the competent regulatory agencies should implement regulations and establish an early risk warning system. Education and protection should be provided for individual investors to maintain financial security and stability. Based on the aforesaid research findings, this study proposed the following three policy recommendations. First, an early risk warning mechanism and a set of emergency measures should be introduced to the A-share stock market, so in the event of the outbreak of major incidents, i.e., the COVID-19 pandemic, market risk associated with investor sentiment fluctuations can be precluded; besides, appropriate regulatory intervention should be made to limit irrational A-share stock market trading and make the stock market stabler. Second, the competent regulatory agency should educate the investors pertinently, improve their expectations, and guide them to respond reasonably to the external shock of the market. Investor sentiment is an important factor that causes financial stock market volatility under the pandemic. Therefore, psychological monitoring or emotional management intervention during a pandemic outbreak helps people not only to identify mental health problems but also to control their emotions and avoid unreasonable investment behaviors. Third, the impact of the pandemic on investor sentiment should be looked at reasonably. In general, although there was a negative impact on investor sentiment, the pandemic was inversely correlated with the pharmaceutical industry and the state-owned firms, i.e., investigation of investor sentiment at the firm level could be important. Stringent pandemic control measures should be combined with other measures in favor of effective optimistic investor sentiment.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

YS: conceptualization, methodology, formal analysis, writing—original draft preparation, and funding acquisition. XH: data processing, formal analysis, and writing—original draft preparation. ZL: methodology, project management, and funding acquisition. All authors contributed to the article and approved the submitted version.

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Explaining People's Worry Levels During the Covid-19 Pandemic: An Analysis of Socio-Economic and Cultural Dimensions

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This paper examines the influence of socio-economic and cultural dimensions (measured at the country level) on what concerns people the most about the Covid-19 pandemic. Based on secondary data, the study considers the opinion of more than 24,000 individuals living in 30 different countries, with national samples weighted to match each country's general population older than 18 years of age. A set of linear Bayesian regressions was applied to 10 different types of worries reported for economic, health, and safety domains. Results demonstrate that socio-economic variables and cultural dimensions complement each other in explaining people's concerns about the effect of the Covid-19 pandemic. An overall view of the analysis also reveals that cultural dimensions exceed socio-economic variables in explaining peoples' worries about health and safety domains. Socio-economic variables are slightly more effective in explaining the worries of the economic domain. Among the cultural dimensions, long-term orientation and uncertainty avoidance are the best in explaining people's worries. The higher the score in long-term orientation, the lower the worry levels expressed by the respondents. Likewise, low scores on uncertainty avoidance generate lower levels of worries due to the Covid-19 pandemic. Finally, health worries produce a positive outcome because they explain a significant reduction in the fatality rate.

Keywords: Covid-19 pandemic, worries, cultural dimensions, long-term orientation, uncertainty avoidance, income

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INTRODUCTION

Worry is a normal phenomenon that affects us all, but probably what we are living through today is by far the most important worry our society has seen during our life span. The world has been facing the largest public health crisis in recent history (Schaw, 2020). Since December 2019, Covid-19 has infected and killed millions of people around the world. This new reality is causing individuals to be worried about their own circumstances and that of many others around them.

A worry has been defined as a disturbing cognition that a state of an object (i.e., my personal health, my country's economic situation, etc.) in some domain of life (i.e., health, economic, social relations, etc.) will become discrepant from it desired state (Boehnke et al., 1998).

This definition encompasses daily worries and prolonged, intense, and uncontrollable worries that might be associated with the clinical diagnosis of anxiety (Borkovec et al., 2004).

The current pandemic has worsened uncertainty not only over physical and mental health but also over the economy, employment, finances, and relationships. Every worry involves some potential danger to a personal or collective object in at least one of the six main domains of life identified by Boehnke et al. (1998): health, safety, environment, social relations, meaning in life, achievement in work and studies, and economics. Freeston et al. (1994) argue that individuals who worry do so because of a reduced ability to tolerate uncertainty. Specifically, in the context of worry, they introduced the concept of intolerance uncertainty by indicating that a primary reason individuals worry is to try to exert some control over situations they face in life with the hope of preventing or reducing future adverse outcomes. Researchers have demonstrated that worry and intolerance of uncertainty are positively related (Ladouceur et al., 2000).

Do we differ in how much worry and uncertainty we can tolerate in life? If so, what could explain the distinct worry levels experienced by people from different nations? Under normal circumstances, extant research demonstrates that people from diverse cultures react differently to different stimuli. Thus, this paper focuses on the influence of socio-economic and cultural dimensions on what concerns people most about the Covid-19 pandemic. Are cultural dimensions able to somehow explain how groups of individuals report their worries about the implications of Covid-19? Is the way individuals react to Covid-19 better explained by socio-economic conditions in the country they are living? Are worries producing a negative outcome under a pandemic situation like Covid-19? These are the main questions addressed in this paper, which to the best of our knowledge, is the first in addressing them. Specifically, we examine the interaction effects of socio-economic and cultural variables on 10 personal and collective concerns that people from 30 different countries may have related to the current Covid-19 pandemic. This study's importance relies on providing some explanations to anticipate the degree of people's concerns and consequences of a disturbing event like a pandemic. MacLeod et al. (1991) argue that worry is a cognitive phenomenon affected by future events coming with uncertainty about potential outcomes, creating anxiety feelings. Research has demonstrated that worry serves to exacerbate anxiety (Dickson et al., 2012). Thus, most of the time worries are associated with adverse outcomes, at least for mental health. However, the impact of worries may be different under a crisis like a pandemic.

The countries covered in this research are quite diverse in terms of socio-economic and cultural conditions. Geographically, they come from The Americas, Europe, Australasia, Asia, Africa, and the Middle East. They were measured almost simultaneously during late March and April 2020.

THEORETICAL FRAMEWORK

This study borrows from Rumination's theory (Martin and Tesser, 1989) to explore if and why individuals show distinct levels of worry when facing similar events like a pandemic. Rumination theory postulates that individuals more disposed to ruminate tend to overemphasize negative information related to what they are experiencing and thus seeing problems as more threatening than they are (Lyubomirsky et al., 1999). Rumination and worry are significantly correlated with each other (Fresco et al., 2002; Watkins et al., 2005), and they share many characteristics (McLaughlin et al., 2006). For instance, both are repetitive, perseverative forms of thought that are self-focused (Borkovec et al., 2004) and are associated with difficulty in switching attention from negative stimuli (Hazlett-Stevens, 2001).

Nonetheless, rumination and worry differentiate from each other in the time orientation dimension. Worry tends to be future-oriented and usually focuses on threats that might occur but have not yet happened. In contrast, although rumination can also involve concerns about possible threats in the future, it primarily entails reminiscing over past events with a negative undertone (Nolen-Hoeksema et al., 2008).

Therefore, this research tests the interaction of socio-economic and cultural dimensions as potential explanatory variables for differences in the level of peoples' worries or concerns reported during the global crisis caused by the Covid-19 pandemic. Besides, it also analyzes the impact of such worries on the number of deaths and fatality rates due to Covid-19 pandemic.

Socio-Economic Influences

Having a high income allows people to stop worrying or worry less about survival and material matters. This is what Li et al. (2016) call the "money buffer effect." In contrast, previous research has hypothesized that economic insecurity would increase people's economic worries (Roth et al., 2017). Income, education, and material possessions, among other variables, are often considered essential resources to allow individuals to advance in society by achieving diverse goals in life. Diener et al. (1995) suggest that economic variables may contribute to worry by blocking or enhancing people's ability to achieve their goals. Thus, poor economic country conditions may deprive its citizens of the means needed to satisfy their goals in life. In addition, national economic problems tend to increase the existence of difficulties among the majority in national society, probably extensively covered by the media, thus capturing people's attention and producing higher worrying levels. Consequently, these societies are expected to have a higher level of a worry than more affluent nations. On the contrary, when economic resources are available, people can use them to reduce threats and worries to their well-being to a more desirable level. Thus, the following hypothesis is put forward:

> *H1*: Country's per capita income negatively affects the worry levels experienced by individuals regarding the Covid-19 pandemic.

Employment rates currently available in each country may also influence the way individuals perceive distinct types of worry. In his classic study about cultural dimensions, Hofstede (2001) reports strong negative correlations between individuals'

stress levels at work and perceived employment stability in the future. More recently, Marlar (2010) says that unemployment is positively related to experience worry, and that this worry intensifies with the length of unemployment condition. Therefore, we propose the following hypothesis:

> *H2*: Country's employment rate negatively influences the worry levels experienced by individuals regarding the Covid-19 pandemic.

Cultural Dimensions Influence

Culture is defined as "a collective programing of the mind which distinguishes one group from another" (Hofstede, 1980, p. 25). The model of cultural dimensions proposed by Hofstede (2001) considers country citizens as a group of individuals who share a set of core values and practices theorized to transfer, influence, and normalize what people believe and how they think and behave (Noort et al., 2016). The extant literature is very generous in showing the link between cultural dimensions and people's behavior and perceptions (e.g., Bolton et al., 2010; Sharma, 2010; Thompson and Chmura, 2015), but very few researchers have focused on the impact of culture on people's concerns and worries, particularly under stressing situations like a pandemic. In a study about worries people commonly experience in their daily life (i.e., not under specific events like a pandemic), Schwartz and Melech (2000) demonstrate that worries have consistent meanings across cultures. Therefore, it is possible to make some broader inferences about the impact of cultural dimensions on different types of worries. This study uses five of Hofstede's national cultural dimensions: power distance (PDI), individualism/collectivism (IND), masculinity/femininity (MAS), uncertainty avoidance (UAI), and long-term orientation (LTO). These five cultural dimensions have been selected as they are the most widely accepted drivers of the behavior of which there are scores for the most part of countries.

PDI is the "extent to which the less powerful members of a society expect and accept that power is distributed unequally" (Hofstede, 2001, p. 98) PDI is an indicator of social hierarchy, respect, wealth, rights and privileges (Sharma, 2010; Song et al., 2018). Low PDI cultures see individuals as moral equals who share primary interests as human beings, where their personal responsibility should transcend their selfish interests (Schwartz and Melech, 2000). This understanding implies the existence among low PDI societies of a natural tendency to voluntarily cooperate and feel concerned for other individuals' welfare in their community. Consequently, these societies put aside selfish interests and worry more about societal problems than personal ones. High PDI nations emphasize a hierarchical system with tight control and unequal distribution of power, roles, and resources to ensure socially responsible behavior (Schwartz and Melech, 2000). As a result of this, individuals in low PDI societies are expected to worry more about themselves and those under their care, rather than the greater society. Consequently, the following hypothesis is proposed:

> *H3*: PDI positively impacts the worry levels of individuals regarding the Covid-19 pandemic.

The cultural dimension of IND indicates that societies value independence and define the self according to individuals' distinctive characteristics, and therefore ties between individuals are loose (Markus and Kitayama, 1991; Hofstede, 2001). In contrast, collectivistic cultures tend to define the self in terms of relationships with others, especially within-groups, emphasizing interdependence, in-group cohesiveness, attention to other peoples' needs, and giving value to social harmony (Song et al., 2018). Collectivism closely links individuals to be part of groups such as family, peers, and society (Triandis, 1995; Cho et al., 2013). De Mooij and Hofstede (2011) posit that it is necessary for individuals to build a relationship that is conducive to trust in collectivistic cultures. As a result, after some time, individuals develop interest and even feelings and worries for an extended group of other people. Collectivistic nations stress maintaining the status quo and circumventing actions that might disrupt the solidarity among group members. Collectivists tend to prioritize group goals over personal interests and benefits; thus, they are more concerned for the public good (Sharma, 2010; Nguyen et al., 2017). On the contrary, individualistic societies allow individuals to pursue their own goals and not worry too much about others in the broader community, even when these are suffering (Schwartz and Melech, 2000). IND may provide a plausible explanation for the pressure Americans are putting on their government to re-open the economy as soon as possible. People in IND societies logically are expected to worry about their own health, safety and income and may not be naturally inclined to pay attention to other individuals' problems because it is not necessarily normative to do that in individualistic cultures. Thus, the following hypothesis is suggested:

> *H4*: IND negatively impacts the worry levels of individuals regarding the Covid-19 pandemic.

MAS has been described as a permanent pursuit of achievement and success, while the dominant values of a feminine culture are caring for other people and pursuing harmony and quality of life (De Mooij and Hofstede, 2011). MAS societies somehow emphasize personal things and divert the attention from problems in the broader society by showing a less-caring attitude for the weak (Song et al., 2018). In contrast, feminine cultures are more communal, emphasizing harmony among individuals, emphasizing getting along well with others, and paying attention to events that might threaten the wider society, which translates into lessening the importance of more personal worries. Hence, the following hypothesis is formulated:

> *H5*: MAS is expected to negatively influence the worry levels of individuals regarding the Covid-19 pandemic.

UAI has been explained by the extent to which individuals feel threatened by situations that are accompanied by uncertainty

and ambiguity (Hofstede, 2001). Hofstede et al. (2010) suggest that UAI indicates peoples' anxiety level toward an ambiguous, unpredictable, and uncertain future. Other researchers conceptualize this cultural dimension as individuals' dependence on implicit or explicit rules, structures, and relationships to get away from the ambiguity experienced in everyday life (Yaveroglu and Donthu, 2002). Countries exhibiting high UAI are less tolerant of unorthodox behaviors and ideas (Song et al., 2018). In countries of strong UAI, people prefer to maintain clarity and adhere to the status quo (Sharma, 2010). If the status quo is challenged, for instance, by a pandemic, they require rules and formality to structure life under the new uncertain conditions. Countries like Italy (UAI = 75) and Spain (UAI = 86), which score high in this dimension, have demonstrated this by imposing a state of emergency, quarantine, etc., as a mean to control the spread of Covid-19. In contrast, countries weak in UAI, such as Sweden (UAI = 29), have released only recommendations to its citizens to keep the social distance. Similarly, individuals living in the latter type of countries like United States (UAI =46) feel uncomfortable with newly imposed restrictions and demand them to be lifted as soon as possible. Consequently, the following hypothesis is postulated:

H6: UAI exercises a positive effect upon the worry level of individuals regarding the Covid-19 pandemic.

Finally, LTO is also expected to exercise some influence on people's concerns about Covid-19 pandemic. Individuals living in societies scoring high in this dimension, perhaps influenced by Confucian ethics, are more perseverant, socially conscious and patient than their counterparts from short term-oriented societies (Steenkamp et al., 1999; Sharma, 2010). Perseverance has been explained "as the conscientiousness that is required to persist over time. It is based on the belief that efforts made today will pay off in the future. Perseverance is needed for mere survival, but its cumulative effect is value-creating; it takes time for some things to gain value." (Lumpkin and Brigham, 2011, p. 1154). LTO societies discount the future and value immediate results much less than short-term oriented cultures (Chen et al., 2005). LTO societies are generally persistent, dynamic in thinking and willing to accept radical changes, and therefore more likely to overcome uncertainties (Sharma, 2010; Nguyen et al., 2017). In contrast, short-term oriented ones are expected to solve issues faster, increasing personal steadiness and stability and enjoying the "here and now" (De Mooij and Hofstede, 2011; Song et al., 2018). Short-term orientation relates with stability and focus on the past or the present (Donthu and Yoo, 1998), whereas LTO implies viewing time holistically, valuing both the past and the future, rather than deeming actions necessary only for their effects in the here and now (Bearden et al., 2006). As a result, the following hypothesis is offered:

H7: LTO has a negative impact on the worry levels of individuals regarding the Covid-19 pandemic.

METHODOLOGY

Data and Measures

Independent socio-economic variables used in this study are *per capita* income estimated in US$ purchasing power parity for 2020 (IMF, 2020) and 2019 employment rate (Euromonitor, 2020) for each country considered. The other independent variables (i.e., cultural dimensions) were taken from Hofstede (2020), which are represented in normalized scores ranging from 0 = low level and 100 = high level of presence of the corresponding dimension. The data on worries or concerns (i.e., dependent variables) were taken from the Consumer Pulse Survey of McKinsey (2020). They collected data at the end of March and April 2020 in 30 different countries, with samples considered representative since they weighted them to match each country's general population older than 18 years of age. The general question presented to respondents was: What concerns you most about the Covid-19 situation? Respondents were asked to declare their level of concern about 10 types of worries on a 5-point Likert scale where 1 = not a concern, and 5 = extremely concerned. The actual data used for the current study in each of the 10 dependent variables relate to the % of respondents who are very concerned or extremely concerned (i.e., points 4 and 5 in the Likert scale). **Table 1** shows the list of countries, their corresponding sample sizes, and the aggregated values for the dependent and independent variables used in this study.

Method

In search for a more aggregated way to present the results of this study, the 10 worries included as dependent variables were subjected to Exploratory Factor Analysis with a non-orthogonal rotation (i.e., Direct Oblimin). Results confirm the presence of only one factor extracting 86% of the total variance. Cronbach alpha for this index achieves 0.98, which is deemed excellent. Consequently, an overall worry index was created as the average of the 10 different types of worries. Nevertheless, based on face validity, the worries were subclassified into three types to better represent their nature: economic, health, and safety. These also achieved excellent levels as indicated by their Cronbach's alpha values: Economic Worries (4-item, 0.96), Health Worries (4-item, 0.95), and Safety Worries (2-item, 0.96). Thus, these aggregated dependent variables were added as the average of their composing variables.

Table 2 shows the correlation coefficients among independent and dependent variables used in this study. The results of this primary step allow anticipating some impact of the independent over the dependent variables. For instance, the socio-economic variables are significantly correlated with all types of worries. In turn, cultural values show some significant correlations, particularly PDI, UAI and LTO.

Next, our analysis focused on testing whether socio-economic and cultural variables may be used to predict worry levels. To accomplish that, linear Bayesian regressions in SPSS 26 with non-informative prior distribution were used. The selection of non-informative prior is used due to the great deal of uncertainty

TABLE 1 | Countries considered in the study (in alphabetical order) and values for the dependent and independent variables.

Country	Sample size	Independent variables							Dependent variables: worries			
		Socio-economic		National cultural dimensions					Economic	Health	Safety	Overall
		Income	Employment Rate	Power distance (PDI)	Individualism/ collectivism (IND)	Masculinity/ femininity (MAS)	Uncertainty avoidance (UAI)	Long-term orientation (LTO)				
Argentina	1,007	19970.52	61.7	49	46	56	86	20	61.50	60.00	74.50	63.50
Australia	669	54799.04	74.1	38	90	61	51	21	41.00	47.50	49.50	45.30
Belgium	604	50904.69	65.2	65	75	54	94	82	30.00	46.75	48.50	40.40
Brazil	1,013	17016.32	64.4	69	38	49	76	44	64.00	72.00	75.00	69.40
Canada	1,034	52144.45	73.5	39	80	52	48	36	45.25	55.00	54.50	51.00
Chile	1,005	27150.38	60.0	63	23	28	86	31	70.75	73.25	87.50	75.10
China	1,216	20984.28	75.5	80	20	66	30	87	21.25	21.75	25.50	22.30
Colombia	1,005	16264.97	61.1	67	13	64	80	13	68.00	70.00	79.50	71.10
Denmark	603	55675.00	75.1	18	74	16	23	35		34.25	32.00	
France	1,003	48640.05	66.6	68	71	43	86	63	34.50	49.50	49.50	43.50
Germany	1,002	55306.21	76.0	35	67	66	65	83	28.75	36.50	30.50	32.20
India	601	9026.87	43.6	77	48	56	40	51	67.50	76.00	83.50	74.10
Indonesia	722	14840.76	65.5	78	14	46	48	62	46.25	47.75	54.00	48.40
Italy	1,009	41582.19	58.7	50	76	70	75	61	50.25	56.50	58.00	54.30
Japan	600	46827.35	77.9	54	46	95	92	88	44.75	41.50	38.50	42.20
Mexico	1,506	21363.00	61.7	81	30	69	82	24	76.75	60.75	82.50	71.50
Nigeria	531	6171.68	53.3	80	30	60	55	13	73.25	81.50	86.00	79.10
Peru	1,012	15398.62	68.7	64	16	42	87	25	58.00	71.25	81.50	68.00
Poland	607	35651.18	62.2	68	60	64	93	38	56.25	74.00	75.50	67.20
Portugal	601	34935.82	69.4	63	27	31	99	28	62.50	78.00	81.50	72.50
Saudi Arabia	510	56912.37	54.9	95	25	60	80	36	34.25	48.25	52.00	43.40
South Africa	535	13965.17	42.0	49	65	63	49	34	76.00	77.00	82.00	77.60
South Korea	600	46451.61	65.2	60	18	39	85	100	35.75	30.25	44.50	35.30
Spain	1,006	43007.50	63.4	57	51	42	86	48	60.50	78.75	85.50	72.80
Sweden	201	55988.99	77.5	31	71	5	29	53	30.00	41.00	36.50	35.70
Switzerland	745	67557.70	79.0	34	68	70	58	74	27.00	34.50	34.00	31.40
Turkey	599	29327.00	48.4	66	37	45	85	46	45.00	58.00	42.00	49.60
United Arab Emirates	510	70441.55	81.2	90	25	50	80		56.50	66.75	71.50	63.60
United Kingdom	1,005	48168.87	74.4	35	89	66	35	51	42.00	55.75		
United States	1,063	67426.84	68.8	40	91	62	46	26	47.75	56.00	58.50	53.20
Total Sample	24,124	19970.52	61.7	49	46	56	86	20	50.18	56.67	60.48	55.49

TABLE 2 | Correlation matrix.

Variables	Socio-economic		National cultural dimensions					Worries			
	Income	Employment rate	PDI	IND	MAS	UAI	LTO	Economic	Health	Safety	Overall
Income											
Employment Rate	0.636**										
PDI	−0.435*	−0.401*									
IND	0.548**	0.224	−0.731**								
MAS	−0.053	−0.060	0.165	0.089							
UAI	−0.072	−0.163	0.425*	−0.385*	0.139						
LTO	0.328	0.332	−0.057	0.057	0.160	−0.002					
Economic worries	−0.629**	−0.559**	0.293	−0.323	−0.010	0.240	−0.697**				
Health worries	−0.501**	−0.555**	0.332	−0.207	−0.041	0.342	−0.675**	0.884**			
Safety worries	−0.563**	−0.533**	0.411*	−0.342	−0.020	0.373*	−0.662**	0.935**	0.939**		
Overall worries	−0.567**	−0.554**	0.294	−0.262	−0.096	0.271	−0.735**	0.969**	0.969**	0.978**	

*Significant at $p \leq 0.05$.
**Significant at $p \leq 0.01$.

in the population parameter. The rationale for choosing Bayesian regression over traditional frequentist methods has been identified by van Schoot and Depaoli (2014). This method is appropriate for parameter estimation with limited information available (Rossi and Allenby, 2003; Carlin and Louis, 2010; Sapsis, 2020) in (1) complex models, (2) when the researcher prefers the definition of probability, (3) when background knowledge can be incorporated into the analysis, and (4) only a small sample is available. Despite the number of individuals sampled in the current study (i.e., 24,000+), all data is aggregated at a country level for each of the 30 countries included, so our analysis is based on 30 observed cases. Thus, the Bayesian point estimator is the mean of the posterior distribution obtained after analysis. This resulting estimator is dominated by sample information (Greene, 2012).

The Bayesian model allows placing the parameters in a credible interval (95%), assuming that these parameters are random, unlike the frequency methods that give a point estimator. Wagenmakers et al. (2018, p. 38) explain the difference between confidence interval and credible interval as follow: "An X% confidence interval for a parameter θ is an interval generated by a procedure that in repeated sampling has an X% probability of containing the true value of θ. Thus, the confidence in the classical confidence interval resides in its performance in repeated use, across hypothetical replications. In contrast, the confidence in the Bayesian credible interval refers directly to the situation at hand." For example, A 95% credible interval ranges from 0.18 to 0.59, which means that one can be 95% confident that the true value of ρ lies between 0.18 and 0.59. In this research, the data come from different countries; therefore, there could be effects of varying magnitude of the explanatory variables on the model's dependent variables, depending on the country. To capture this heterogeneity in small sample sizes, as in this study, it makes more sense to place the random parameters in a credible interval (Bayesian approach) rather than determining a point estimator that may be biased (parametric multiple linear regression).

The estimator obtained by Bayesian methods can be interpreted in the same way as the estimators by classical approaches as if they were maximum likelihood estimators (Train, 2009). To calculate the Bayesian estimator (i.e., the mean of the posterior distribution), it is necessary to use simulation techniques (Train, 2009). In this case, random values were extracted from the posterior distribution (Gelman and Rubin, 1992) to allow inference from Bayesian estimators.

Using the available observations, two socio-economic variables (i.e., *per capita* income and employment rate) and five cultural dimensions (i.e., power distance, individualism/collectivism, masculinity/femininity, uncertainty avoidance, and long-term orientation) have been specified.

A maximum number of 10,000 iterations were established for each model, and measures of model fit based on the Bayesian factor, the value of adjusted R^2, and the model's overall significance were obtained. The Bayes' factor contrasts the hypothesis of strength in evidence provided by the sample information to support the proposed model (Kass and Raftery, 1995). It contrasts the hypothesis that the model resulting from Bayesian estimation is preferable to the model that tests

the null hypothesis. The scale proposed by Jeffreys (1961) will be used to assess the magnitude of the Bayesian factor. The credible intervals were estimated at 95% confidence; therefore, for the significance comparison of each parameter, it was considered that if 0 is within the credible interval, then the null hypothesis that the estimator is nonzero cannot be rejected, and therefore, it will not be significant at 5%.

RESULTS

Results are presented based on the Bayesian regressions for each of the dependent variables used to measure worries or concerns in samples from the 30 countries. In all models run, the measures of goodness of fit are satisfactory, the measure of R^2 (as displayed by SPSS software) is at an adequate level, and the factor of Bayes >100 indicates that the robustness of the information in the sample supports the proposed model decisively (models are significant at 1%). The estimators and measures of fit for each Bayesian regression model are detailed in **Table 3**. The variance of the estimator and the credible intervals at 95% are reported in **Table 4**.

To facilitate a more aggregated view of the results, the 10 different worries considered in this study have been classified into three main domains of life identified by Boehnke et al. (1998): economic (4), health (4), and safety (2).

Economic Worries

Worry for the Country's Economy

The average *per capita* income ($\beta = -0.610$; $p \leq 0.05$) is a significant negative factor explaining this worry, which means that an increase in income reduces concern for the national economy situation. At the same time, three cultural dimensions have a significant impact on this worry. UAI has a positive effect ($\beta = 0.383$; $p \leq 0.05$); whereas PDI ($\beta = -0.426$; $p \leq 0.05$) and LTO ($\beta = -0.185$; $p \leq 0.05$) resulted in significative negative influence. An increase in PDI and LTO produces a decrease in concern for the country's economy; conversely, a greater aversion to uncertainty produces a greater concern for the national economy. Altogether, the independent variables explain a considerable level of the variance of worry for the country's economy (Bayesian $R^2 = 0.66$).

Not Being Able to Get the Supplies I Need

Only two variables were significant in this type of worry, and both were producing a negative impact on the dependent variable: Income ($\beta = -0.613$; $p \leq 0.05$) and LTO ($\beta = -0.367$; $p \leq 0.05$). This negative coefficient for income indicates that people will reduce their concern for this worry as income increases in a country. Similarly, as LTO increases, the level of worry moves in the opposite direction. The general model explains a sizable portion of the dependent variable variance (Bayesian $R^2 = 0.72$).

Negative Impact on My Job or Income

Income inversely affects the concern for a negative impact on the work or income ($\beta = -0.422$; $p \leq 0.05$), suggesting that an

TABLE 3 | Bayesian regression analysis, worries indicators as dependent variables.

Dependent variables	Independent variables							Adjusted R^2			Model fit	
	Demographics		Cultural dimensions									
	Income US$ PPP	Employment Rate	Power distance	Individualism	Masculinity	Uncertainty avoidance	Long-term orientation	Total	Socio-economic	Cultural dimensions	Bayes factor	Sig.
Economic Worries	**0.000**	**−0.402**	**−0.273**	**−0.006**	**0.085**	**0.184***	**−0.298***	**0.752**	**0.397**	**0.355**	**6109.758**	**< 0.001**
1. The country's economy	−0.610*	−0.489	−0.426*	0.225	0.067	0.383*	−0.185*	0.656	0.247	0.409	350.333	< 0.001
2. Not being able to get the supplies I need	−0.613*	−0.045	−0.070	0.040	0.139	0.121	−0.367*	0.719	0.435	0.284	1777.115	< 0.001
3. Negative impact on my job or income	−0.422*	−0.459	−0.180	−0.123	0.163	0.190*	−0.333*	0.788	0.410	0.378	54971.990	< 0.001
4. Not being able to make ends meet	−0.392*	−0.519	−0.162	−0.040	0.123	0.176	−0.259*	0.709	0.430	0.279	2016.539	< 0.001
Health Worries	**0.000**	**−0.323**	**0.015**	**0.255**	**−0.084**	**0.283***	**−0.308***	**0.707**	**0.194**	**0.513**	**1901.387**	**< 0.001**
5. Overall public health	−0.661*	−0.065	0.007	0.375*	−0.025	0.292*	−0.350*	0.608	0.197	0.411	89.634	< 0.001
6. Health of my relatives in vulnerable populations	−0.353	−0.255	−0.048	0.286	−0.175	0.333*	−0.341*	0.628	0.100	0.528	155.030	< 0.001
7. My personal health	−0.371	−0.731*	−0.009	0.158	0.064	0.174	−0.280*	0.630	0.229	0.401	163.469	< 0.001
8. Contributing to spread the virus	−0.467*	−0.258	0.110	0.203	−0.200	0.334*	−0.260*	0.703	0.158	0.545	1625.515	< 0.001
Safety Worries	**−0.001**	**−0.277**	**0.035**	**0.147**	**−0.078**	**0.332***	**−0.379***	**0.698**	**0.143**	**0.555**	**859.625**	**< 0.001**
9. Safety of myself or my family	−0.428*	−0.440	−0.041	0.130	−0.022	0.322*	−0.335*	0.726	0.177	0.549	2228.434	< 0.001
10. Taking care of my family	−0.643*	−0.055	0.112	0.201	−0.111	0.320*	−0.424*	0.630	0.119	0.511	166.953	< 0.001

*Coefficient is significant at the 0.05 level.

TABLE 4 | Ninety five percent credible interval and Bayesian estimator variance.

	(1)			(2)			(3)			(4)			(5)		
	95% cred. Inter.			95% cred. Inter.			95% cred. Inter.			95% cred. Inter.			95% cred. Inter.		
	Lower	Upper	Var	Lower	Upper	Var	Lower	Upper	Var	Lower	Upper	Var	Lower	Upper	Var
Income PPP US$ 2020	−0.986	−0.234	0.036	−0.984	−0.243	0.035	−0.744	−0.100	0.026	−0.731	−0.054	0.029	−1.103	−0.220	0.050
Employment rate 2019	−1.074	0.096	0.088	−0.619	0.528	0.084	−0.960	0.042	0.064	−1.045	0.008	0.071	−0.752	0.622	0.121
Power distance	−0.811	−0.040	0.038	−0.461	0.321	0.039	−0.511	0.150	0.028	−0.509	0.185	0.031	−0.446	0.460	0.052
Individualism	−0.072	0.523	0.023	−0.255	0.336	0.022	−0.378	0.132	0.017	−0.308	0.228	0.018	0.025	0.724	0.031
Masculinity	−0.178	0.312	0.015	−0.109	0.386	0.016	−0.047	0.373	0.011	−0.097	0.344	0.012	−0.312	0.263	0.021
Uncertainty avoidance	0.181	0.585	0.010	−0.084	0.326	0.011	0.017	0.363	0.008	−0.006	0.358	0.008	0.055	0.529	0.014
Long Term orientation	−0.369	−0.002	0.009	−0.547	−0.187	0.008	−0.490	−0.176	0.006	−0.424	−0.094	0.007	−0.565	−0.135	0.012
		(6)			(7)			(8)			(9)			(10)	
Income PPP US$ 2020	−0.733	0.026	0.037	−0.794	0.053	0.046	−0.824	−0.110	0.033	−0.796	−0.059	0.035	−1.155	−0.132	0.067
Employment Rate 2019	−0.846	0.355	0.089	−1.373	−0.054	0.111	−0.813	0.298	0.079	−1.016	0.135	0.085	−0.851	0.742	0.162
Power Distance	−0.437	0.341	0.039	−0.443	0.426	0.048	−0.256	0.476	0.034	−0.417	0.334	0.036	−0.413	0.637	0.070
Individualism	−0.015	0.586	0.023	−0.178	0.493	0.029	−0.079	0.486	0.020	−0.164	0.423	0.022	−0.205	0.606	0.042
Masculinity	−0.422	0.072	0.016	−0.212	0.340	0.019	−0.433	0.032	0.014	−0.263	0.218	0.015	−0.444	0.223	0.028
Uncertainty Avoidance	0.129	0.536	0.011	−0.054	0.401	0.013	0.142	0.525	0.009	0.123	0.520	0.010	0.045	0.594	0.019
Long Term Orientation	−0.526	−0.156	0.009	−0.487	−0.074	0.011	−0.434	−0.086	0.008	−0.514	−0.157	0.008	−0.673	−0.174	0.016

The first column lists all the independent variables. The 10 additional columns correspond to each of the dependent variables signaled by numbers from 1 to 10 in the bottom part of **Table 3**.

increase in income reduces this concern. With respect to culture, two dimensions were significant: UAI ($\beta = 0.190$; $p \leq 0.05$) and LTO ($\beta = -0.333$; $p \leq 0.05$). These coefficients indicate, on the one side, that the higher a country scores in UAI, the more people will worry about the negative impact of the Covid-19 pandemic on their job and income. On the other side, short-term oriented people tend to express more worries about the negative effects of the Covid-19 pandemic on the job and income. Overall, the independent variables' explanatory power on the negative impact on one's job or income is the highest among all regression models run (Bayesian $R^2 = 0.79$).

Not Being Able to Make Ends Meet

Income is impacting in a significant and negative way the concern of not being able to pay the monthly expenses ($\beta = -0.392$; $p \leq 0.05$). An increase in income reduces this concern. Concerning cultural dimensions, only LTO is significant ($\beta = -0.259$; $p \leq 0.05$), meaning that short-term oriented societies tend to worry more about not having enough to cover monthly expenses. The total variance explained by income and long-term orientation in the dependent variable is also very good (Bayesian $R^2 = 0.71$).

Overall, the economic worries achieve an adjusted Bayesian $R^2 = 0.75$ when using socio-economic and cultural variables as independent variables. To estimate each set of independent variables' partial contribution, a Bayesian multiple regression with a stepwise approach was used. Results indicate that 0.40 is contributed by the socio-economic variables and 0.35 from cultural dimensions.

Health Worries

Overall Public Health

In general, public health concern is significantly impacted by income ($\beta = -0.661$; $p \leq 0.05$), signifying that an increase in its value reduces public health concern. In terms of culture, three dimensions are significant: IND ($\beta = 0.375$; $p \leq 0.05$), UAI ($\beta = 0.292$; $p \leq 0.05$) and LTO ($\beta = -350$; $p \leq 0.05$). Greater IND, higher UAI and short-term orientation lead to greater concern for public health. All in all, this regression model explains a substantial part of the dependent variable (Bayesian $R^2 = 0.61$).

Health of My Relatives in Vulnerable Populations

Interestingly, only the cultural dimensions of UAI ($\beta = 0.333$; $p \leq 0.05$) and LTO ($\beta = -0.341$; $p \leq 0.05$) are significant in the model. A higher level of UAI increases the concern for relatives in the population at risk, and a greater LTO produces a decrease in this concern. Even though only two variables were significant, an important level of the total variance in the dependent variable was achieved (Bayesian $R^2 = 0.63$).

My Personal Health

This worry is the only one where the country's employment rate achieves a significant role in explaining the dependent variable ($\beta = -0.731$; $p \leq 0.05$). The national employment rate has a significant influence on reducing personal health concerns. Regarding culture, LTO is the only one achieving a significant level in the standardized coefficient ($\beta = -0.280$; $p \leq 0.05$),

pointing out that a greater LTO reduces personal health worries. As has been the case in all regressions explained above, this model reaches a good explanatory level (Bayesian $R^2 = 0.63$).

Contributing to Spread the Virus

This dependent variable decreases significantly as the country's income increases ($\beta = -0.467$; $p \leq 0.05$). The cultural dimensions that significantly influence this worry are UAI ($\beta = 0.334$; $p \leq 0.05$) and LTO ($\beta = -0.260$; $p \leq 0.05$). The regression model shows that a higher level of UAI and a short-term orientation increase the concern for spreading the virus. Overall, the explanatory level in the dependent variable is also very good (Bayesian $R^2 = 0.70$).

In summary, the health worries achieve an adjusted Bayesian $R^2 = 0.71$ when using socio-economic and cultural variables as independent variables. To estimate the partial contribution of each set of independent variables, a Bayesian multiple regression with a stepwise approach was run. Results indicate that 0.20 is contributed by the socio-economic variables and 0.51 from cultural dimensions.

Safety Worries

Safety of Myself or My Family

Income is a negative and significant variable explaining concern for oneself or one's family ($\beta = -0.428$; $p \leq 0.05$), thus suggesting that an increase in the average income reduces this concern. With respect to cultural dimensions, two variables were significant: UAI ($\beta = 0.322$; $p \leq 0.05$) and LTO ($\beta = -0.335$; $p \leq 0.05$). Scoring higher in UAI and being short-term oriented contributes to a society worrying more about oneself and family's safety. The general model explains a significant level of variance of the dependent variable (Bayesian $R^2 = 0.73$).

Taking Care of My Family

In this model, income achieves a significant negative coefficient ($\beta = -0.643$; $p \leq 0.05$). An increase in income reduces the concern for the family. With respect to culture, the same two dimensions were significant: UAI ($\beta = 0.320$; $p \leq 0.05$) and LTO ($\beta = -0.424$; $p \leq 0.05$). Again, scoring high in UAI and being short-term oriented make society worry more about taking care of one's family. Overall, the model also explains a very good level of the variance in the dependent variable (Bayesian $R^2 = 0.63$).

Altogether, the safety worries achieve an adjusted Bayesian $R^2 = 0.70$ when using socio-economic and cultural variables as independent variables. To estimate each set of independent variables' partial contribution, a Bayesian multiple regression with a stepwise approach was used. Results indicate that 0.14 is contributed by the socio-economic variables and 0.56 from cultural dimensions.

Are Worry Levels Explaining Covid-19 Deaths?

To investigate the potential effect of the worries included in this study over what many may consider the most significant outcome in this Covid-19 crisis (i.e., deaths), two new Bayesian regression analyses were modeled. The country-level indicators of the number of deaths per 100 K population and the fatality rate over the total number of infected people per country as of November 30, 2020, were used as dependent variables for these estimates (John Hopkins University, 2020). We argue that worries play the role of an antecedent of death per 100 K and fatality rate because worry levels were measured 7 months before those. Consequently, we are testing whether worry levels somehow impact the dependent variables after a few months.

Table 5 shows that the 95% credible intervals for the three independent variables do include 0, indicating that there is no effect in predicting death per 100 K. The regression model for deaths per 100 K inhabitants explains only 12% of its variance but is not significant, probably due to the omitted variable bias.

For their part, as **Table 5** indicates, the overall model for the fatality rate is significant, explaining 24% of the variance in the case fatality variable (Bayesian $R^2 = 0.24$). However, there is no evidence that economic worries and

TABLE 5 | Bayesian Estimates.

Parameter	Posterior			95% credible interval	
	Mode	Mean	Variance	Lower bound	Upper bound
A: Bayesian estimates of coefficients for death per 100 K as dependent variable					
Intercept	21.549	21.549	795.267	−34.176	77.274
Health_Worries_Index	−0.372	−0.372	1.733	−2.974	2.230
Eco_Worries_Index	−2.459	−2.459	1.794	−5.106	0.187
Safety_Worries_Index	2.819	2.819	2.078	−0.030	5.667
Error Variance[#]	1357.569	1604.399	257409.757	896.675	2846.251
B: Bayesian estimates of coefficients for case fatality as dependent variable					
Intercept	3.211	3.211	1.109	1.130	5.293
Health_Worries_Index	−0.142[*]	−0.142	0.002	−0.239	−0.045
Eco_Worries_Index	0.082	0.082	0.003	−0.016	0.181
Safety_Worries_Index	0.056	0.056	0.003	−0.050	0.162
Error Variance[#]	1.894	2.238	0.501	1.251	3.971

[#]*Assume standard reference priors.*

[*]*Coefficient is significant at the 0.05 level.*

A: Adjusted $R^2 = 0.120$, Bayes Factor = 0.167, and Significance = 0.112. B: Adjusted $R^2 = 0.240$, Bayes Factor = 0.967, and Significance = 0.022.

safety worries are good predictors of the dependent variable. In turn, health worries are the only significant predictor, having a significant negative influence on the case fatality rate, which is a positive outcome for society. Results in **Table 5** show that the posterior mean of the regression coefficients of health worries is −0.142, while for economic worries is 0.082 and for safety worries is 0.056. We can interpret this estimate such that one unit increase in the health worries leads to a decrease of 0.142 units in the case fatality on average. The corresponding 95% credible interval of [−0.239, −0.045] indicates a 95% probability that the regression coefficient of health worries lies in the population within the corresponding credible interval. Also, the 95% credible interval does not include 0, so it is reasonable to conclude that health worries affect the prediction of case fatality.

So, being worried about health conditions seems to positively affect after a few months by reducing the number of casualties due to the pandemic. One possible explanation for this significant impact is that higher levels of health worries will probably mean that people will engage in more prosocial behavior. Serrano-Montilla et al. (2021) report that perceived threat is indirectly (*via* empathic concern) linked to prosocial tendencies. Among those prosocial tendencies, we may mention adopting more measures to avoid getting infected and disseminating the virus to others (reducing time spent outside the home, keeping social distance, wearing masks, and washing hands frequently). As a result of the prosocial behavior, it would be expected a lower level of fatality rate.

DISCUSSION AND IMPLICATIONS

Table 6 summarizes the evidence from our work that is statistically significant against each hypothesis. Overall, there is enough evidence to fully support three hypotheses that deal with income, UAI and LTO upon the different types of worries. Two other hypotheses, one dealing with the socio-economic variable of the country's employment rate and the other one focusing on PDI's cultural dimension, received marginal support. Lastly, two hypotheses were not supported at all. MAS was non-significant in all the Bayesian regressions run in this study. Surprisingly, IND was significant in only one of the worries but in the opposite direction to the expected one (see more on this further down in the paper).

This study contributes to our current knowledge of how people react in terms of worries caused by a crisis event like a pandemic. First, as proposed at the outset, Rumination theory is a good foundational support for the analysis of the potential impact on important outcomes such as deaths resulting from a pandemic. This theory posits that individuals more disposed to ruminate usually overemphasize negative information related to what they are experiencing and thus seeing problems as more threatening than they are (Lyubomirsky et al., 1999). However, a contribution from this study is that worry levels in the health domain result in a positive outcome for countries by reducing the fatality rate.

Second, socio-economic variables and cultural dimensions complement each other in explaining people's concerns about the effect of the Covid-19 pandemic. Altogether, socio-economic variables and cultural dimensions explain between 61 and 79% of the variation on any of the worry levels considered in this study. The negative relationship between income and worries could be explained by the fact that, in higher-income economies, household savings levels are more likely to occur. Thus, people there may enjoy greater financial security. An overall view of the analysis makes evident that cultural dimensions as a group exceed socio-economic variables in explaining peoples' worries due to the Covid-19 pandemic in the health and safety domain. As one may expect, socio-economic variables are slightly better than cultural variables in explaining worries classified in the economic realm. Higher scores in socio-economic

TABLE 6 | Summary of hypotheses.

Hypotheses	Evidence
H1: Country's *per capita* income negatively affects the worry levels experienced by individuals regarding the Covid-19 pandemic.	Supported in eight out of 10 Bayesian regressions. The two worries where H1 is not supported belong to the health dominion of worries: health of my relatives in vulnerable populations and my personal health.
H2: Country's employment rate negatively influences the worry levels experienced by individuals regarding the Covid-19 pandemic.	Supported in only one out of 10 Bayesian regressions (My personal health).
H3: PDI positively impacts the worry levels of individuals regarding the Covid-19 pandemic.	Supported in only one out of 10 Bayesian regressions (The country's economy).
H4: IND negatively impacts the worry levels of individuals regarding the Covid-19 pandemic.	Not supported. Surprisingly in one Bayesian regression, a significant coefficient is found in the opposite direction (Overall public health).
H5: MAS is expected to negatively influence the worry levels of individuals regarding the Covid-19 pandemic.	Not supported.
H6: UAI exercises a positive effect upon the worry levels of individuals regarding the Covid-19 pandemic.	Supported in seven out of 10 Bayesian regressions. The three worries where H6 is not supported are: Not being able to get the supplies I need, not being able to make the ends meet (both belonging to the economic dominion of worries), and my personal health.
H7: LTO has a negative impact on the worry levels of individuals regarding the Covid-19 pandemic.	Supported in 10 out of 10 Bayesian regressions.

variables may give people a powerful sense of safety and confidence, reducing the intensity of worries.

Third, the best explanatory cultural dimensions upon worries are LTO and UAI. LTO significantly reduces the degree of concern expressed by the respondents. Likewise, low UAI also generates lower levels of worries due to the Covid-19 pandemic. Somehow unexpected, the cultural dimensions of PDI, MAS, and IND are marginally or non-significant in explaining peoples' concerns. One may speculate that PDI's lack of impact upon worries is because none of its traditional assumptions can be fully developed under a pandemic crisis. On the one side, low PDI societies are expected to portray individuals as moral equals that transcend their selfish interests, so people may voluntarily cooperate with each other to improve the general welfare. On the other side, in high PDI cultures, people are required to meet role obligations that may contradict personal interests. However, under a pandemic situation, the freedom to decide what to do may be put aside, and governments' decisions may be imposed to "all individuals," no matter their role in society, to control the crisis. Besides, no matter the status in the community, all individuals feel vulnerable to potential adverse consequences in a pandemic situation. In the case of MAS, societies encourage mastering and changing the surrounding world to their will by overcoming any barrier that may appear. In contrast, feminine cultures try to preserve it and usually are less worried about what could be out of control. But under the current Covid-19 pandemic, for which there is not an effective treatment yet discovered, there seem to be no significant differences in the way societies worry about potential consequences, no matter if they can be classified as masculine or feminine. Lastly, a surprising finding is the absence of any negative effect of IND upon the worries reported by respondents. Above all was the discovery that IND impacts positively, not negatively as expected, on the worry of "overall public health." As stated earlier, IND cultures value independence and define the self according to individuals' distinctive characteristics, thus having loose ties with others, whereas collectivistic cultures explain the self in terms of relationships with others, emphasizing interdependence, in-group cohesiveness, attention to other peoples' needs, and closely linking individuals through an interest in each other. It seems that a pandemic like Covid-19 permeates all theoretical considerations that are traditionally associated with IND and collectivism. Under a crisis like this, and until we have an effective antidote available, the individual may affect others, and the society may affect individuals with fatal consequences.

Overall, the main contribution in cross-cultural psychology can be the supporting evidence that the national cultural dimensions, specifically LTO and UAI, are suitable explanatory variables upon the worry levels included in this study. In turn, worry levels, particularly in the health domain, contribute positively to reducing the fatality rate under a pandemic like Covid-19. As such, worry levels are not always harmful as we usually see them. Consequently, governments may positively reduce their countries' fatality rate by developing and implementing informative campaigns highlighting the potential health risks due to a critical situation like a pandemic.

LIMITATIONS AND FUTURE RESEARCH

The first limitation of this study relates to the number of countries considered; although it is much larger than that of other studies dealing with worries (Schwartz and Melech, 2000), it represents around 15% of all the world countries. Including additional countries in future research may provide more evidence of the interaction between socio-economic and cultural variables and their impact on worries. Having a database with more observations (i.e., more countries) may allow for further analysis, such as testing to see whether worry levels mediate the relationship between socio-economic and cultural variables upon the death of people in a pandemic situation. For such a test, it is recommended sample sizes of at least 50 observations (Fritz and MacKinnon, 2007; Schoemann et al., 2017).

A second limitation relates to the independent variables used here. Other objective socio-economic measures may be included in future studies, such as the Gini coefficient, which reports income inequality. Likewise, cultural dimensions beyond those offered by Hofstede could be used, including additional ones proposed by The Globe Project, Schwartz and Trompenaars.

Third, the data used for all analyses in this study are at a country, not an individual level; thus, it is impossible to identify any variability within the sample. Also, Denmark, United Arab Emirates, and the United Kingdom presented missing values for one variable each.

Fourth, additional dependent variables, such as those related to mental health, may be used to test the effect of worry levels in the population.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

Ethical review and approval were not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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Mental Health and the Role of Physical Activity During the COVID-19 Pandemic

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The COVID-19 pandemic and its related public health restrictions are having an increasingly serious impact on mental health, and measures need to be taken to curb this trend. The positive relationship between physical exercise and mental health has been well-established, but during the COVID-19 pandemic, with various restrictions, the space and facilities for physical exercise are limited. This article explores the relationship between physical exercise and mental health during the COVID-19 pandemic based on the latest research findings published in 2019–2021. We offer a novel model that consists of three central arguments. First, physical exercises during COVID-19, especially supervised exercises, are conducive to enhancing happiness and improving mental health. Second, physical exercise reduces people's anxiety, sadness and depression during the COVID-19 pandemic. Third, the maintenance and improvement of mental health are related to the intensity and frequency of physical exercise. Intensive and frequent physical exercise are conducive to maintaining mental health. Finally, this article proposes important directions for future research.

Keywords: mental health, COVID-19 pandemic, coping behavior, integrated framework, physical activity

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INTRODUCTION

Physical activities, personal contact with colleagues, friends and family have been limited due to public health measures to curb the spread of COVID-19, such as quarantine, lockdown, self-isolation, and maintaining social distance. People experienced a general decline in well-being, deterioration in mental health, and an increase in psychological distress such as stress, anxiety, depression, and feelings of isolation (Chtourou et al., 2020; Gupta et al., 2021). This negative impact may, in turn, affect compliance with public health measures (Puyat et al., 2020). Hence, there is a need to explore and identify alternative and complementary activities that promote mental health and well-being during COVID-19.

It is well-established that physical activity or exercise is essential to improve and/or maintain physical and mental health and improve the quality of life (Warburton et al., 2006; Bird et al., 2021; Vancini et al., 2021). Various physiological and psychological mechanisms have been proposed to explain the positive effects of physical activity (Anderson and Shivakumar, 2013; Stubbs et al., 2017). Physiologically exercise may increase the levels of hormones, endorphins and Brain-derived Neurotrophic Factor (BDNF), which could make people feel happy and less stressed (Harber and Sutton, 1984).

Moreover, psychologically, exercise gives people the opportunity to have "time out" from the stressor, and regular exercise improves self-efficacy to overcome the difficulties they face (Petruzzello et al., 1991).

The COVID-19 pandemic has heightened people's attention to the positive effects of exercise on physical health. During the pandemic, the news media disseminates a great deal about the therapeutic effects of physical activities on physical health and people with mild coronavirus infection. Regular and long-term physical exercise enhances the body's immune surveillance capabilities, acts as an anti-inflammatory agent, reduces the risk of developing numerous chronic diseases, and improves the general level of physical health and disease prevention and resistance (Shephard et al., 1991).

Initial evidence has shown that individuals can maintain and promote mental health through exercise during the pandemic (Gupta et al., 2021). However, measures restricting the spread of COVID-19 have led to a decline in physical activity for most children and adolescents, especially among boys and older children and adolescents (Yomoda and Kurita, 2021). Compared with the first wave of the COVID-19 pandemic, physical activities in the second wave dropped by 3.1 percentage points (Gupta et al., 2021). Quarantine or self-isolation further reduces the amount and intensity of physical activities (Ammar et al., 2021), resulting in a general increase in inactivity and sedentary behavior (Schuch et al., 2020). On the other hand, the pandemic has triggered people to engage more in various activities to enhance mental health, but the number of people participating in physical exercise decreased, and the number of people participating in other activities increased (Gupta et al., 2021). Especially in the period of stricter prevention and control, the number of people reporting participation in camping, other family activities (such as sewing, puzzles and board games), and virtual group activities such as virtual churches has increased (Gupta et al., 2021). Therefore, it is imperative to address the following questions: Do physical exercises at home still maintain and/or improve the level of mental health? What range and types of sports activities do people usually engage in during a pandemic? What is the relationship between the intensity and frequency of indoor physical exercise and the improvement of mental health?

This article aims to address the above questions by building an integrated conceptual model and proposing directions for future research. It contributes to the literature by synthesizing the latest empirical findings since the outbreak of the COVID-19 pandemic in an integrated framework and providing a conceptual analysis of physical activity and mental health in times of a global pandemic.

THE MECHANISMS OF PHYSICAL ACTIVITY AND MENTAL HEALTH

Scholars have suggested various mechanisms that could potentially explain the positive effect of physical activity on mental health (Anderson and Shivakumar, 2013; Stubbs et al., 2017). Studies have revealed a variety of potential physiological mechanisms. For instance, it is well-acknowledged that, in addition to the improvement of physical health (Warburton et al., 2006), exercise may reduce stress hormones in the body, such as cortisol and adrenaline, and increases the levels of endorphins, which make people feel happy, optimistic and relaxed (Harber and Sutton, 1984). Moreover, exercise increases BDNF, which may help relieve the anxiety symptoms (Asmundson et al., 2013).

From the psychological perspective, there are three potential mechanisms. First, regular exercise increases the exposure to anxiety-related sensations, which helps to reduce anxiety sensitivity, resulting in a better mental health condition (Smits et al., 2008). Second, exercise may help build a sense of self-efficacy, improve self-image and confidence, which enhance the sense of control over stressful situations (Petruzzello et al., 1991). Third, exercise provides a distraction from stressors to enjoy the moment of physical activity, thus effectively reduce anxiety (Petruzzello et al., 1991).

COPING BEHAVIORS

Coping behaviors in this article refer to what people do in response to the stressful situation during COVID-19 (Cypryańska and Nezlek, 2020), and engaging in various types of physical activities is considered as a coping strategy to mitigate the negative effect on mental health and enhance well-being (Faulkner et al., 2020). According to the stress coping framework proposed by Lazarus and Folkman (1984), when people recognize the existence of a threat, they will be involved in either emotion-focused or problem-focused coping. Engaging in physical is a problem-focused, active coping, as people attempt to lessen the impact of pandemic-related stress. Studies have shown that fear and anxiety may trigger coping behaviors (Teasdale et al., 2012; Jin et al., 2020), which include following the public authority's preventive guidelines, such as wearing a facemask, washing hands, social distancing, and active engagement in physical exercises (Harper et al., 2020; Winter et al., 2020).

Lockdown during the pandemic has greatly reduced the outdoor activity time, and the outdoor activity space has been compressed, and people take home-based exercise as a coping strategy to promote psychological well-being (Faulkner et al., 2020; Vancini et al., 2021). The beneficial effects of home-based physical activities on mental health may be higher than other activities, such as religious activities, puzzles, and board games (Puyat et al., 2020; Gupta et al., 2021). Studies have focused on home-based physical exercise models that can be carried out by the general population to promote mental health from different perspectives.

Home-based exercise provides a safe alternative to public gyms and individual group fitness classes (Gupta et al., 2021). Studies have reported on the positive effects of family-based exercise programs on the anxiety, mood, social and emotional health of elderly cancer patients (Loh et al., 2019). Home exercise can include aerobic activities such as dancing (Gupta et al., 2021), balance and flexibility training, such as yoga (Ransing et al., 2020), muscle strength exercise, such as weightlifting (Gupta

et al., 2021) endurance training and others (de Almeida et al., 2020). For example, as one of the common ways of indoor physical exercise, yoga exercise during the epidemic can reduce the perceived stress (Büssing et al., 2012), enhance emotional control and improve self-efficacy (Wang and Szabo, 2020), self-confidence and overall quality of life. Yoga is considered a non-pharmacological active intervention for mental problems (such as stress, fear) and mental disorders. It can be used alone or in combination with other interventions (Ransing et al., 2020), and it is one of the important measures to prevent or control mental health problems during the epidemic.

Exergames that use electronic products for human-computer interaction (such as simulated swimming, boating, cycling, running, and walking) may also help maintain and/or improve physical and mental health during the pandemic (Viana and de Lira, 2020). These active video games use visual and auditory stimuli to allow individuals to perform physical activity through interaction with motion and motion sensors (Viana and de Lira, 2020). Studies have shown that exergames have a positive effect on improving mood disorders (Byrne and Kim, 2019). Healthy young women performing a 20-min exergame Zumba fitness training at moderate intensity can reduce the level of anxiety (Viana et al., 2017).

AN INTEGRATED CONCEPTUAL FRAMEWORK

The control measures to limit the spread of the pandemic, such as lockdown, quarantine, self-isolation, social distancing, and wearing of masks have restricted both indoor and outdoor sports and fitness activities (Giustino et al., 2020; Schuch et al., 2020). Under the influence of various factors such as the general lack of time and space and the increase in family roles (Lum and Simpson, 2021), the types of physical activities that people can participate in have changed (Gupta et al., 2021). People's engagement in exercise has also changed (Faulkner et al., 2021). Generally, there are three key observations on the impact of the COVID-19 pandemic on physical exercise: (a) the pandemic triggers people's participation in physical activity; (b) the pandemic control measures inhibit physical activity, and (c) physical exercise helps improve the mental health and immune system (Constandt et al., 2020; Cheval et al., 2021; Maltagliati et al., 2021).

First, while the pandemic has brought a global disaster, it has triggered a new movement of people engaging in high-quality physical exercise. The information of physical activity benefits has effectively reached more people, which has become an opportunity for the education and development of the physical exercise system (Li and Liu, 2020). Government departments, sports companies, schools, families, opinion leaders, and ordinary citizens have been involved in the discussion of the benefits of sports and other physical activities (Faulkner et al., 2020; Li and Liu, 2020). The lack of exercise at home and the common awareness of improving immunity during the pandemic have prompted a large number of people to pay more attention to sports and exercise (Zhong et al., 2020). The pandemic has also greatly changed people's traditional views that sports and exercise must rely on professional venues, facilities and mentoring and that these activities can be carried out at home and with family members (Zhong et al., 2020).

Second, there are many difficulties and challenges for people to engage in physical exercise because of the Covid-related restrictions. The pandemic and its infection control measures have restricted people's participation in collective sports. Reduced physical activity during the pandemic has triggered more mental health problems (Gupta et al., 2021). Moreover, the economic and financial distress resulted from the pandemic may distract people from engaging in physical exercise (Salameh et al., 2020). Physical education faces new major challenges: students' home exercise may not reach the level required, online sports games lack physical and face-to-face social interaction Yuan (Li and Yuan, 2020). In colleges and universities, this situation is not optimistic. The attitude toward exercise is not positive enough; there is a significant gap between girls and boys in terms of physical exercise; the level of physical self-esteem of girls is relatively low (Li and Yuan, 2020).

Third, despite the challenges, studies on physical exercise during the pandemic confirm the positive impact of physical exercise on mental health and the immune system. Regular physical exercise during the pandemic can relieve psychological stress, improve the public's mental state, and effectively enhance the immune systems (Lou and Yan, 2020; Vancini et al., 2021). Scholars have called for active physical exercise to improve physical fitness, relieve stress, and promote physical and mental health (Constandt et al., 2020; Cheval et al., 2021; Maltagliati et al., 2021).

We synthesize the major thinking and findings in the extant literature in a conceptual model as presented in **Figure 1**, which depicts the relationships between measures to control the spread of COVID-19, physical activities and the deterioration of mental health, and the major mediating and moderating factors.

Antecedents: Factors Hindering Physical Activity

Physical activity during the pandemic can reduce psychological pressure, promote physical and mental health, and improve the quality of life (Lum and Simpson, 2021). Both planned and unplanned physical activities are important explanatory variables for mental health, whether it is before or during the lockdown (Bird et al., 2021). We first explore the factors that hinder routine sports or activities during the COVID-19 lockdown.

Existing Health Status

Lack of physical exercise during the pandemic is likely to cause physical health problems. Sedentary behavior and physical inactivity often cause chronic and high-level inflammation (Zbinden-Foncea et al., 2020), which may make people more susceptible to the most severe form of COVID-19 (Vancini et al., 2021). Studies have shown that people with immunosuppression and chronic low-grade inflammation (especially the elderly) tend to have more severe forms of disease and higher mortality when infected with the COVID-19 virus (Yang et al., 2020). Therefore, moderate physical exercise is particularly helpful, as it

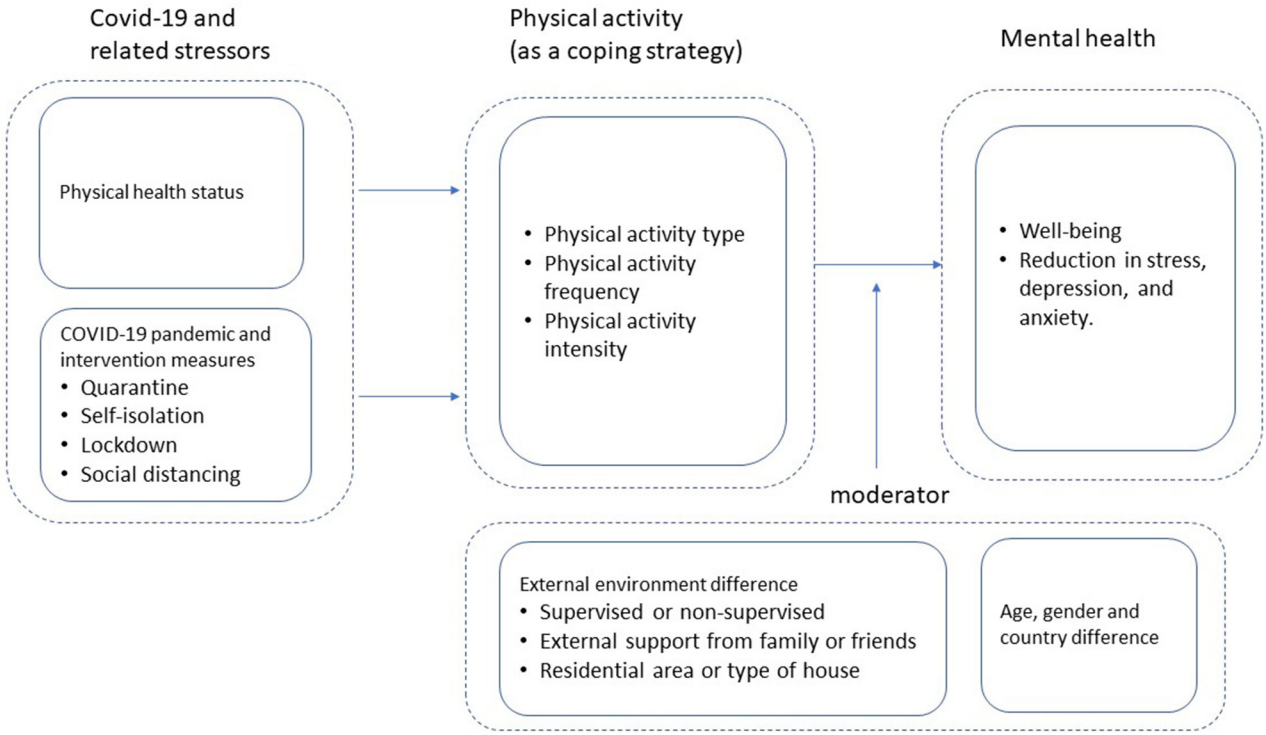

FIGURE 1 | Integrated conceptual framework.

can improve immunity and provide immune protection (Vancini et al., 2021). Unfortunately, existing poor health conditions may hinder physical activity (Lum and Simpson, 2021), thereby further increase the risk of infection. The level of severity of the illness to be high if infected, causing even more serious health problems.

Quarantine, Self-Isolation, and Lockdown

The lack of facilities and time constraints caused by quarantine, self-isolation and lockdown are important factors hindering the development of sports and other activities (Lum and Simpson, 2021). Along with the lengthening of the pandemic lockdown cycle, non-physical exercises such as positive thinking exercises, meditation and art, and light physical activities such as walking became more likely to be engaged in, while heavy physical activities such as cycling, hiking and jogging were substantially less likely to be engaged in Gupta et al. (2021). Motivation to exercise for some people may be weakened because of quarantine, self-isolation or lockdown (Maugeri et al., 2020). It is reported that the total physical activity of the population is significantly reduced during periods of quarantine, self-isolation and lockdown, with profound negative effects on people's mental health and well-being (Maugeri et al., 2020).

Social Distancing

Maintaining social distance is an important intervention to combat the spread of the virus because of the high infectivity and pathogenicity of COVID-19 (Brooks et al., 2020). However, the social distancing measure itself is not conducive to mental health (Salari et al., 2020), because of the reduced level of face-to-face physical activity and group physical activity (Moreira-Neto et al., 2021). The inhibited social interaction brought by social distancing may exacerbate the psychological distress brought by the pandemic (Carvalho Aguiar Melo and de Sousa Soares, 2020).

Physical Activity Type, Intensity, and Frequency

The restricted collective activities during the pandemic have triggered mental health problems (Gupta et al., 2021), which heighten the importance of physical activity through alternative forms of exercise (Antunes and Frontini, 2021), especially, home-based exercise has been very popular as a coping strategy in such difficult times.

Types of Physical Activity

Nearly all types of physical activity are helpful and both physical exercise training and relaxation training can buffer the negative effects of stress on general health and mental health (Klaperski and Fuchs, 2021). Participation in physical activities at home such as yoga, dancing to music, exergames and other home-based exercises have been shown to alleviate a wide range of mental illness symptoms, improve anxiety, mood, social and emotional health (Chtourou et al., 2020; Puyat et al., 2020). Yoga, an ancient exercise focusing on both body and mind, is found to be very effective for improving mental well-being, through both psychological reappraisal and autonomic stress coping behaviors

(Kinser et al., 2012). Wang and Szabo (2020) suggest that nearly all types of yoga are beneficial for the relief of stress. Exergames, which are exercises based on video games, appeal to the younger population to exercise at home, while the internet may further enable social interaction with friends remotely (Viana and de Lira, 2020).

Frequency of Physical Activity

The frequency of physical activity may not have the same degree of positive impact on mental health during the COVID-19 pandemic, while more physical activity is likely to be associated with higher levels of mental health (Maugeri et al., 2020). The number of participants participating in exercise is a moderator of the relationship between stress and overall health, and physical health alone cannot moderate the relationship between stress and mental health (Klaperski and Fuchs, 2021). People who become inactive have higher levels of loneliness, sadness and anxiety compared to those who are consistently active in physical activity (Werneck et al., 2021). Those who participated in at least one physical activity had significantly lower depression, anxiety, and psychological distress scores, compared to those who did not participate in physical activity (Gupta et al., 2021). People who did not exercise for a long time had a higher chance of experiencing loneliness and sadness (Werneck et al., 2021).

Physical Activity Intensity

The impact of physical activity intensity on mental health varies. Individuals who engaged in more active exercise behaviors during the pandemic reported better mental health and well-being (Faulkner et al., 2021). However, the step counting program alone was not associated with mental health scores (Bird et al., 2021). For those participants who participated in moderate to vigorous exercise ($\geq$30 min) or vigorous exercise ($\geq$15 min) daily, the level of anxiety and depression and the concurrent occurrence of depressive and anxiety were almost lower (Schuch et al., 2020). Physical exercise should be adjusted according to the health level of the participants and that a progressive intensity and a training volume model should be adopted (Chtourou et al., 2020).

Moderators

Gender, Age, and Country Differences

Gender

There is a gender difference in exercise behaviors during the COVID-19 pandemic. It was found that women's exercise behaviors became more active during the COVID-19 pandemic (Faulkner et al., 2021). In general, there is a general reduction in exercise behavior caused, the reduction was greater for the male than the female group (Giustino et al., 2020).

Age

The COVID-19 pandemic may have different effects on exercise behaviors by different age groups. It was found that the exercise behavior of young people between 18 and 29 years old became more passive (Faulkner et al., 2021). In order to overcome the impact of COVID-19 on mental health, exercise intensity should be tailored for different ages. Adults must accumulate at least 75 min of high-intensity activities and 150 min of moderate-intensity activities each week. Children and adolescents who actively play at home or around the family can reduce the amount of training by 30% (Chtourou et al., 2020).

Country

Faulkner et al. (2021) compared the differences in exercise behaviors in the United Kingdom, Ireland, New Zealand, and Australia and their impact on mental health and well-being, and found that physical activity in different countries did not very much, but the level of mental health seems higher in New Zealand than in the other countries in their survey (Faulkner et al., 2021).

Contextual Variables

The major contextual variables include exercise monitoring (or supervising and mentoring), support from family and friends, and the place of residence.

Monitoring

Ideally, a physical activity program should be evidence-based, self-sustaining, feasible, acceptable, appropriate, and not dependent on remote or face-to-face supervision (Ransing et al., 2020). However, compared with self-directed exercise, supervised health care is more likely to stimulate exercise, thereby reducing self-reported depressive symptoms (Moreira-Neto et al., 2021). However, the pandemic restrictions make face-to-face supervision infeasible, and remote supervision has become a viable alternative (Moreira-Neto et al., 2021). Even home-based exercise requires mentoring programs such as smartphone applications and wearable sensors for monitoring (Chtourou et al., 2020) to help optimize activities, to achieve the desired benefits and minimize the potential risks that occur when certain activities are excessive or incorrectly performed (Puyat et al., 2020).

Support From Family or Friends

Support from family and friends are important for the engagement of physical activity during the outbreak. Women, especially those going through menopause, can increase their physical activity levels by making plans, setting goals, and exercising with friends or family (Lum and Simpson, 2021). Moreover, parental support may help children maintain or increase their physical activity levels during a pandemic (Yomoda and Kurita, 2021).

The Place of Residence

The location of residence had an impact on the practice of physical activity during the epidemic. Studies have shown that the decline in physical activity during the pandemic was smaller among children living in detached houses, houses with more space, rural areas, and those with more family members (Yomoda and Kurita, 2021).

FUTURE RESEARCH DIRECTIONS

Physical activity plays an important role in maintaining and/or improving mental health. Future studies will generate more insights through the collection of data from large

sample sizes, the use of cross-cultural contexts with adequate control for confounding factors, randomized controlled trials, and the adoption of more robust and thorough statistical analyses. Cross-cultural, multicenter studies using the same intervention and clearly defined components (currently missing) should be encouraged to explore the feasibility of physical activity as an effective intervention to maintain and improve mental health.

Physical Activities in Times of Pandemic

Further research is needed to understand how to maintain physical activity during a major public health crisis. For example, given the various pandemic restriction measures, what physical activities are more conducive to people's physical and mental health? Which physical activities do people prefer to engage in to promote physical and mental health? How can the pandemic be used as an opportunity to further increase the awareness of the importance of physical activity? Physical exercise is often seen as a form of stress management, but causal evidence on the stress-buffering potential of exercise remains very limited (Klaperski and Fuchs, 2021). Additional research is needed to further explore the stress-buffering potential of physical exercise.

Mediating and Moderating Effects

Future studies could further explore the mediating and moderating effects between physical activity and mental health in the context of major public health events.

Demographic Variables

Future research could focus on different gender and age groups to explore the motivations that motivate these groups to participate in physical activity during the pandemic and the magnitude of the moderating effects of gender and age in the relationship between physical activity and mental health. Moreover, the effects of different income levels and different racial/ethnic or cultural differences could be explored. Research can target specific groups (such as men, young people) that are most vulnerable to the negative effects of restriction measures (Faulkner et al., 2021), and explore instrumental measures to encourage physical exercise.

Country Context

Future research could compare the impacts of public health restrictions on exercise behaviors, and subsequently, mental health in different countries, especially those with different national cultures and income levels. Online supervised exercise has been proven to help improve mental health during the pandemic, however, it is not possible for some low- and middle-income countries to widely adopt this mode of exercise due to the lack of proper resources, especially internet access (Ransing et al., 2020). Therefore, further research is required to explore alternative measures to increase the level of physical exercise in different country contexts.

Modes of Exercise

The type of physical activity may moderate the relationship between exercise and mental health outcomes (Gupta et al., 2021). The amount of time required and the levels of intensity vary across the types of exercise, future research should compare the stress-buffering effects of different exercise types and the effects of alternative stress-modifying interventions to determine which interventions are most effective for different groups of people under different contexts (Klaperski and Fuchs, 2021). Future research may explore how suitable home-based exercise programs such as yoga (Ransing et al., 2020), non-pharmacological interventions such as home-based aerobics should be used in conjunction to address mental health issues during a pandemic. The effectiveness of physical activity in comparison with other leisure activities could also be examined.

Exercise Monitoring/Mentoring Modes

Some studies have found that supervised exercise is more motivating than self-directed exercise, thereby reducing depressive symptoms (Moreira-Neto et al., 2021). However, little is known about the motivation for the different modes of exercise. Therefore, future studies may examine motivation as a moderating factor to explain people's engagement in certain modes of exercise and the subsequent effects on mental health.

Measures for Promoting Physical Activities

The extant literature is rather silent on strategies or concrete measures to encourage various physical activities during times of health crisis such as COVID-19. Yarimkaya and Esentürk (2020) recommended several strategies that families could adopt to help children with autism spectrum disorders practice physical activity during the pandemic. However, strategies of physical activity for the general healthy population are also urgently needed during this difficult time. Further research is required to test the effectiveness of the various recommended strategies and their suitability for the general public.

CONCLUSIONS

This article explores the impact of the COVID-19 pandemic on physical activities and the evidence that physical activities can maintain and/or improve mental health based on a review of the literature on physical exercise and mental health published between 2019 and 2021. The empirical evidence reported in those studies shows that in the context of COVID-19, maintaining regular exercise is effective, and engaging in alternative modes of physical activity is a key strategy to maintain mental health and well-being (Maugeri et al., 2020). Further research is called for to contribute to the development and implementation of public health interventions to encourage various physical activities across different social groups in different contexts.

AUTHOR CONTRIBUTIONS

XA, XW, and ZL contributed to the general conception and the conceptual framework of the study. XA, XW, JY, and ZL took part in collecting relevant data (including research findings) and

worked together to complete the first draft of the manuscript. Analysis of the data on which conclusion was based were mainly done by XA, XW, and ZL. XA and ZL revised and finalized the manuscript. All authors contributed to the article and approved the submitted version.

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CONCEPTUAL ANALYSIS
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COVID-19, Economic Impact, Mental Health, and Coping Behaviors: A Conceptual Framework and Future Research Directions

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The COVID-19 pandemic has caused serious economic and social consequences. Recent research shows that the pandemic has not only caused a physical health crisis but also caused many psychological and mental crises. Based on the contemporary cognitive-behavioral models, this article offers a conceptual analysis of how the pandemic affects individual mental health and coping behaviors from the perspective of individual economic status, individual context, and social context. The analysis shows that (1) the pandemic has led to increased economic uncertainty, increased unemployment and underemployment pressure, increased income uncertainty, and different degrees of employment pressure and economic difficulties; (2) these difficulties have stimulated different levels of mental health problems, ranging from perceived insecurity (environmental, food safety, etc.), worry, fear, to stress, anxiety, depression, etc., and the mental health deterioration varies across different groups, with the symptoms of psychological distress are more obvious among disadvantageous groups; and (3) mental health problems have caused behavior changes, and various stress behaviors such as protective behaviors and resistive behaviors. Future research directions are suggested.

Keywords: COVID-19 pandemic, economic difficulty, employment difficulty, mental health, coping behavior

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INTRODUCTION

The current COVID-19 pandemic is still ongoing, and it is concerning that we still do not know how long it will last and what long-term effects it will have. Despite the successful development of vaccines, the medical capacity to completely treat this disease is still limited. Non-pharmaceutical interventions (NPIs), such as increasing handwashing, reducing physical contact, wearing masks in public places, maintaining social distance, quarantine, and isolation, are still the main strategies for handling this pandemic (Van Bavel et al., 2020; Gössling et al., 2021). The social and economic consequences of the pandemic are devastating: almost half of the global workforce is at risk of losing their livelihoods, tens of millions are at risk of falling into extreme poverty, and millions of companies are facing existential threat (Alauddin et al., 2021). In addition to the pandemic itself, the economic impact of the crisis brings heavy psychological stress to individuals, causing mental health problems, and may trigger

long-lasting behavior changes. Other pandemic-related factors may also cause psychological distress, including mandatory use of face masks (Wang et al., 2020a), lockdowns (Le et al., 2020), lack of access to medical services (Hao et al., 2020; Tee et al., 2021), dissatisfaction with health information (Tee et al., 2021), perceived discrimination (Wang et al., 2021), and stress about returning to work (Tan et al., 2020).

Prior behavioral science research focuses on perceived threats, stress, and coping (Van Bavel et al., 2020). In the early stages of the pandemic, the physical health risks associated with the COVID-19 pandemic have received extensive attention from the academic community (Mehta et al., 2020; Odayar et al., 2020), and there is growing research attention on the risks of mental health associated with the spread of the pandemic (Auerbach and Miller, 2020; Xiong et al., 2020; Wang et al., 2020a). The focal attention since the outbreak of the pandemic has been the psychological distress as a result of the pandemic itself (Jungmann and Witthöft, 2020) or the adverse economic impact of the pandemic (Bierman et al., 2021). However, it is still unclear how the pandemic control measures cause mental health problems through economic impact (Murakami et al., 2021). Many scholars believe that the measures taken during the pandemic may cause people to suffer more economic losses and fall into economic difficulties, thereby causing serious mental health problems (Timming et al., 2021), while some scholars believe that although the pandemic may cause huge economic losses, people's mental health status has not decreased (Murakami et al., 2021). Therefore, it is necessary to conduct a conceptual analysis of the economic impact of the pandemic and mental health by synthesizing the relevant findings in existing literature (Ali et al., 2021).

This study aims to develop a conceptual framework linking the pandemic to individual economic problems, unemployment, mental health, and behavior change. The main research questions are (1) what kind of individual economic stress has the pandemic caused? 2) what mental health problems have this individual economic stress caused, and to what extent? 3) does the mental health problem vary by different groups or individuals? 4) what kind of behaviors may be caused by the deterioration of mental health?

THEORETICAL BACKGROUND

According to the World Health Organization, mental health includes subjective well-being, self-efficacy, autonomy, ability, intergenerational dependence, intellectual or emotional potential. When there is a problem with mental health, there will be a decline in subjective well-being and various negative emotions (such as fear, nervousness, loneliness, and despair), and symptoms such as mental distress (such as anxiety, depression, and stress) will appear (Hossain et al., 2020). Mental health issues are considered as public health problems that are often affected by factors related to occupation, employment opportunities, and economic stress (Ali et al., 2021). Many scholars have examined the impact of economic poverty and unemployment on mental health (Jin et al., 1997). Disaster mental health research also shows that people generally suffer emotional or psychological distress following a disaster (Pfefferbaum and North, 2020).

Mental Health Amid the Pandemic

The World Health Organization (2020) proposes mental health indicators for the COVID-19 pandemic: painful symptoms and perceived danger. Mental distress is a short-term state of emotional distress, often driven by limited resources to manage stressors and daily life needs (Patel and Rietveld, 2020). The pandemic can become a major source of stress, especially in chronic anxiety and financial stress (Van Bavel et al., 2020). Mental distress has become the focus of research on mental health problems amid a large-scale crisis (Cheng et al., 2004; Wang et al., 2020b). Preliminary evidence suggests that symptoms of anxiety, depression, and self-reported stress are common psychological responses to the pandemic (Rajkumar, 2020). Salari et al. (2020) reported that the prevalence of stress was between 29.6 and 33.7%. In addition to mental distress, the pandemic and corresponding interventions or preventive measures may make people feel insecure, fearful, uncertain, lonely, or isolated (Auerbach and Miller, 2020), which exacerbates the psychological distress (Pfefferbaum and North, 2020).

Public Health Interventions

Non-medical interventions or control measures during the pandemic may weaken social relationships that can help people to regulate emotions, cope with stress, and maintain adaptability (Rimé, 2009; Jetten et al., 2017; Williams et al., 2018), exacerbate feelings of loneliness and isolation (Hawkley and Cacioppo, 2010; Holmes et al., 2020), and become a risk factor for more serious mental health disorders (Cacioppo et al., 2006). The stresses experienced during the pandemic, especially the economic stress, may cause difficulties in interpersonal relationships, destroy psychological resources, and make normal interactions difficult (Karney, 2020). The impact of the pandemic interventions on mental health vary across different (employment) groups.

Contemporary Cognitive-Behavioral Models and Mental Health

The contemporary cognitive-behavioral models (Taylor and Asmundson, 2004; Asmundson et al., 2010) explore the key role of traits, triggering events, cognition, and behaviors in the development and maintenance of health anxiety, which can be used to analyze mental health problems during the pandemic period. Jungmann and Witthöft (2020) believe that during the pandemic, idiosyncratic health anxiety regulates the relationship between excessive online information search and viral anxiety, and adaptive emotions serve as a buffer between the two. The "Role Tension" model explores mental health issues from the perspective of role conflicts. It believes that individuals with multiple social roles may experience role conflicts, resulting in stress and adverse mental health (Oomens et al., 2007). The broader behavioral immune system theory (McKay et al., 2020) explores the specific path of disease anxiety,

and believes that disgust tendency and sensitivity, and emotional response are all part of the behavioral immune system.

CONCEPTUAL FRAMEWORK

Figure 1 summarizes the themes from recent research findings in a conceptual framework.

The Mechanism of COVID-19's Impact on Mental Health

In addition to the pandemic itself, the lockdown, quarantine, or self-isolation policies that aim at fighting the pandemic, the involuntary underemployment or unemployment have led to individuals' economic difficulties and mental health problems of varying degrees for many people. The economic impact on individuals seems to further exuberate the suffering from the pandemic (Bierman et al., 2021).

Employment Uncertainty

Employment problems caused by the pandemic include involuntary unemployment (Piltch-Loeb et al., 2021), involuntary underemployment (Pierce et al., 2020; Ferry et al., 2021), employment uncertainty and insecurity (Wilson et al., 2020), job instability or inability to work (Sirviö et al., 2012), and others. Studies have shown that involuntary underemployment and/or unemployment are related to poor mental health (Dooley et al., 2000; Pharr et al., 2012), especially those who are unemployed during economic crises or recessions (Uutela, 2010; Drydakis, 2015; Fiori et al., 2016). It is reported that crisis-related unemployment has led to a sharp rise in psychological disorders in low- and middle-income countries (Uutela, 2010). Despite the government measures to limit the economic impact, the involuntary underemployment or unemployment caused by the epidemic is prominent.

The impact of the pandemic on mental health varies (Pierce et al., 2020). Long-term unemployed people are most vulnerable to adverse mental health effects (Pierce et al., 2020), and those who were employed and retired in the months before the pandemic experience worse than expected mental health conditions (Ferry et al., 2021). Reduced work has different effects on the mental health of different groups. People who are in a poor health condition or self-isolated, and those who have their work reduced due to care responsibilities, have a higher degree of psychological distress (Ferry et al., 2021). The higher the work insecurity caused by the pandemic, the more severe the symptoms of depression (Wilson et al., 2020). As the pandemic continues, the fear of the pandemic itself has not increased mental health problems, but the deterioration of the labor market and the increase in the unemployment rate may intensify people's fear of unemployment, thereby increasing the degree of mental distress (Timming et al., 2021). In addition, due to the lockdown, people's work routines can be broken. Remote work, interruption of work activities due to lockdown measures, or increased workload due to the needs of the pandemic may also become factors affecting mental health (Rossi et al., 2020).

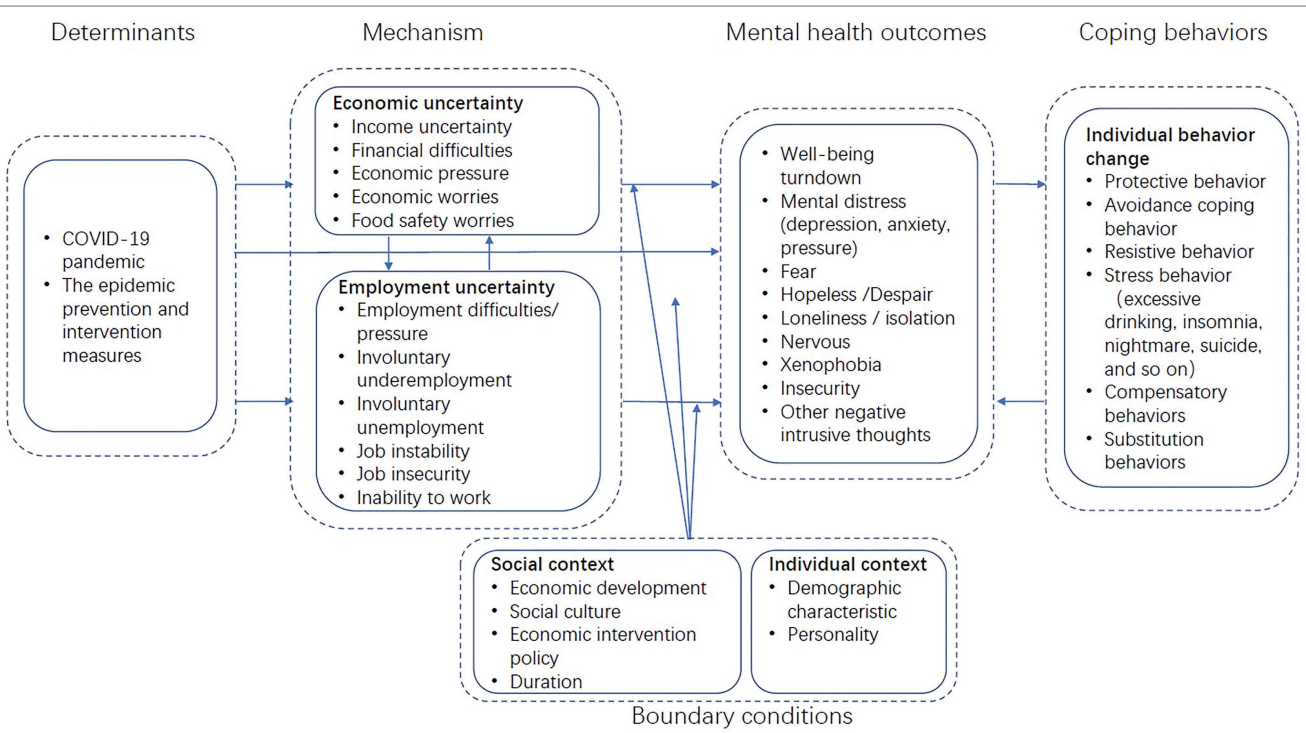

FIGURE 1 | Conceptual framework.

Economic Uncertainty

The analysis of individual economic distress during the pandemic usually focus on short-term economic distress or economic stress, such as personal income uncertainty, personal financial difficulties, salary reduction and other economic (income) losses (Piltch-Loeb et al., 2021), as well as the expected long-term financial impact, such as depletion of savings and/or retirement funds (Piltch-Loeb et al., 2021).

There are two possible ways in which economic distress mediates the impact of the pandemic on psychological distress. One is the economic hardship or economic threat triggered by the pandemic itself. Individual economic loss, economic hardship, or economic threat was significantly associated with mental health (Ali et al., 2021). The pandemic has led to increased risks of depression, anxiety, stress, despair (Pettinicchio et al., 2021), insomnia (Hossain and Ali, 2021), and other common mental health problems. The negative relationship between economic distress and mental health may be a cumulative process. As exposure to distress extends, the average level of individual sufferings increases (Bierman et al., 2021). At the later stage in the pandemic, economic-related anxiety may be a major predictor of psychological distress (Timming et al., 2021).

Second, the unemployment and employment transition triggered by the pandemic affects the financial situation, which in turn affects psychological distress (Thomas et al., 2007). The economic recession triggered by the pandemic and the increase in economic uncertainty has led to business bankruptcy or downsizing, increased involuntary underemployment or unemployment, increased uncertainty in personal income, and increased likelihood of individuals or families experiencing financial difficulties and economic pressure, consequently triggering large scale mental health problems (Kimhi et al., 2020).

Coping Behaviors

The direct consequence of the pandemic's impact on mental health is the change of personal behavior and habits. Studies on past epidemics and pandemics have shown that negative emotions such as anxiety and stress during the epidemic may lead to different behavior patterns.

Positive Defensive Behavior

Humans are born with a set of defense systems against ecological threats (Mobbs et al., 2015). The main emotional response during a pandemic is fear. When people feel capable of responding to the threat of the pandemic, fear can cause individual behavior changes, but if people feel powerless, a defensive response occurs. Positive defensive behavior includes protective, defensive (avoidance), and substitution behaviors.

Protective Behavior

Mental health problems, such as high anxiety, during the epidemic may produce protective behaviors or compensatory behaviors (Wheaton et al., 2012), including washing hands frequently, wearing masks, increasing cleaning of items, social distancing, and other restrictions. Protective behavior can be voluntary (Rubin et al., 2009) or compliant with government regulation (Fragkaki et al., 2021). In addition, people actively engage in physical activities to cope with stress and anxiety (Ai et al., 2021).

Defensive (Avoidance) Behavior

Such behavior includes avoiding touching public goods, strangers, keeping a distance from "patients," avoiding densely populated places and public transport (Rubin et al., 2009), or even resigning from jobs that are perceived to be dangerous (Yin and Ni, 2021).

Substitution Behavior (E.g. Using Technologies)

Service provision based on digital and artificial intelligence technology has become a possible solution to replace human service provision (Nayal et al., 2021), triggering changes in consumer behavior by using technology-mediated services (such as robots) to replace manual services (Kim et al., 2021).

Negative Resistance or Disruptive Behaviors

Resisting Behavior

People with low economic status are more likely to be vigilant about the public health information they receive are less willing to take recommended safety measures and may be more susceptible to "fake news" (Van Bavel et al., 2020). Misunderstandings and worries about the pandemic may also cause the public to refuse to comply with preventive measures (Prati et al., 2011). When people are less worried about the pandemic, they are less likely to engage in hygiene behaviors (such as washing hands), comply with social distance regulations, or be vaccinated if vaccines are available (Taylor, 2019). People also resist or refuse to participate in protective actions proposed by the government when they maintain an optimistic bias about the consequences of the outbreak (Fragkaki et al., 2021).

Panic Consumption Behavior

During the pandemic, a large number of customers stocked up on daily necessities to avoid the expected future threat due to uncertainty and panic arising from perceived scarcity, resulting in panic buying (Omar et al., 2021). People flooded hospitals and clinics unnecessarily when they misunderstood their minor illness as a sign of a serious infection (Asmundson and Taylor, 2020a, 2020b).

Negative Idleness or Sabotage Behavior

Anxiety is an important driving force of behavior (Taylor, 2019). Overly anxious individuals may engage in socially disruptive behaviors, especially for frontline service workers who are directly exposed to the outbreak (e.g., hotel staff), and may result in negative idleness (e.g., tardiness and absenteeism) or even disruptive behaviors or sabotage (Karatepe et al., 2021).

Excessive Stress Behavior

Anxiety and depression caused by the economic difficulties and employment difficulties caused by the crisis may result in various excessive stress behaviors, such as alcoholism (Ahmed

et al., 2020) drug abuse (Nagelhout et al., 2017), even suicide (Milner et al., 2013), etc.

The Boundary Conditions

Sociodemographic Factors

The impact of economic or employment difficulties caused by the pandemic on mental health may be related to socio-demographic factors, including age, gender, ethnicity, family size, occupation, and income (Ferry et al., 2021). Age is one factor. Young people are more likely to have a higher level of anxiety and stress due to the pandemic and corresponding intervention measures than the elderly (Mann et al., 2020; Salameh et al., 2020; Hu and Qian, 2021; Ribeiro et al., 2021). Young people with mental health problems are especially likely to experience adverse health, well-being, and employment outcomes with long-term consequences (Bauer et al., 2021). However, there are also arguments that the elderly may have greater financial difficulties due to the increase in medical expenses during the epidemic, which may trigger mental health problems (Van Bavel et al., 2020), and the elderly's negative health consequences have been long-term ones (Van Bavel et al., 2020).

Gender is another one. Studies have shown that women are more likely to have higher levels of anxiety and stress when faced with possible physical health problems (Salameh et al., 2020; Ferry et al., 2021; Ribeiro et al., 2021). However, when there is the fear of losing their job and the economic anxiety surrounding this possibility, the psychological distress level is more serious for male than female employees (Timming et al., 2021). The third factor is ethnicity. Black and ethnic minority respondents have a higher level of economic anxiety (Mann et al., 2020). The study by Timming et al. (2021) shows that, compared with non-Hispanic respondents, Hispanic respondents are significantly more anxious about losing their jobs. The fourth factor is family size and the number of children. Respondents from families with no children have lower levels of economic anxiety (Mann et al., 2020). People living non-marital life have higher levels of psychological distress (Ferry et al., 2021).

Occupation is the fifth factor. People working at the emergency and customer-facing services, such as doctors, medical staff, police forces, frontline volunteer organizations, and bankers, have a higher risk of infection and subsequent mental stress (Shammi et al., 2020). The mental health of the unemployed, self-employed, and private professionals is worse than that of government professionals (Ali et al., 2020) for increased income (or economic) uncertainty caused by the pandemic (Patel and Rietveld, 2020) or for self-isolation or social distancing measures (Auerbach and Miller, 2020).

The sixth factor is income status. Most studies show that economic hardship resulting from the pandemic may make those disadvantaged groups (e.g., those living in poverty, low-income families, homeless, and refugees) the most vulnerable to experience the corresponding negative consequences (Van Bavel et al., 2020; Długosz, 2021; Hu and Qian, 2021). The mental health of people with disabilities and chronic diseases (Pettinicchio et al., 2021), living alone, and socially marginalized people is even more hostile (Kwong et al., 2020). However, some studies have suggested that the pandemic has a greater impact on the mental health of employees from high-income families (Ferry et al., 2021).

Personality Traits and Psychological Conditions

Personality traits and psychological conditions play an important role in the formation of mental health. Fisher et al. (2021) suggested that depressed and anxious psychological states during the epidemic were associated with diminished energy, functional efficiency, optimism, creativity, engagement, and the ability to focus and solve problems, all of which are necessary for social and economic participation. During the pandemic, those with low collective self-esteem, low responsibility, and low openness to experience have higher levels of economic anxiety, as do those with high levels of neuroticism, perceived vulnerability to illness, and attribution from large group activities (Mann et al., 2020). People with mental and physical health conditions may have higher levels of depression and anxiety because they are more likely to be unemployed and are prone to have higher levels of depression and anxiety (Hao et al., 2020; Kwong et al., 2020; Jung et al., 2021). Extreme loneliness is the main cause of psychological distress (Mikocka-Walus et al., 2021).

Emotional responses are part of the behavioral immune system. McKay et al. (2020) suggested that emotional reactions such as aversive tendencies and sensitivities are moderators of people's disease sensitivity and anxiety. High perceived risks, especially economic risks, are significantly associated with less positive emotions and more negative emotions, leading to more severe mental health problems (Han et al., 2021). The "optimism bias" may help individuals to avoid negative emotions (Van Bavel et al., 2020); however, it may not be conducive for people to engage in behavior change in response to non-pharmacological interventions while individuals with high levels of anxiety and high perceived severity are more likely to be involved in behavior change (Fragkaki et al., 2021).

External Environment

The complex factors of population density, health care capacity, limited resources and existing poverty, environmental factors, social structure, cultural norms, the number of people already infected, and the rapidly occurring community transmission of COVID-19 virus in a country or region can all contribute to public fears, which may lead to higher levels of mental health problems (Shammi et al., 2020).

Level of Economic Development or Socio-Economic Crisis

People in low- and middle-income countries may have higher levels of stress, anxiety, and depression than those in high- and middle-income countries (Tee et al., 2021). In lower-middle-income countries with socio-economic crises, political instability, dense population and limited resources, the stress and anxiety during the pandemic are high (Salameh et al., 2020). Even in high-income countries such as Canada and the United Kingdom, deterioration in mental health has been reported, and are increasing along with the extension of the pandemic period (Zajacova et al., 2020).

Government Economic Intervention Policies or Welfare Policies

Policies that reduce economic stress (e.g., economic interventions such as emergency response benefits) may alleviate the level of mental health deterioration in the early stages of a pandemic by reducing economic hardship and making people less worried about their economic situation (Zajacova et al., 2020). Vaccine-based interventions help to mitigate the economic impact of the outbreak (Meltzer et al., 1999).

FUTURE RESEARCH DIRECTIONS

Mental Health Management

Monitoring and Preventive Measures

For policymakers, health authorities and health care professionals, it is very important to understand the impact of health anxiety on behavior. Future research should investigate the monitoring and preventive measures for different industries or different groups so as to help the government, service providers and employers understand the groups that should be given priority in mental health support (Ferry et al., 2021) and better conduct mental health rehabilitation. More studies are needed to examine the risk assessment of the pandemic, reliable risk communication with risk groups, the establishment of a cross-departmental management task force, and other measures.

Social Protection Measures and Relief Programs

Social protection measures include daily demand provision and social support (Jung et al., 2021) and cash transfer programs (Bauer et al., 2021). Future research should examine how to effectively use social protection measures (or relief plans) to solve the short-term and long-term effects of economic uncertainty caused by large-scale epidemics or economic crises on mental health. First, it is necessary to study how to support individual and family cash transfer programs to support young people's future life opportunities and break the vicious circle between mental illness and poverty that puts many young people at a disadvantage in socio-economic and mental health (Bauer et al., 2021). Second, it is essential to study the physical and mental health of the most economically disadvantaged during economic downturns (Holmes et al., 2020; Bierman et al., 2021), and specialized relief measures that target low-income populations (Shammi et al., 2020). Third, future research should consider both material and social supports in the examination of social protection measures (or relief programs). Fourth, future research attention needs to be paid to employee assistance programs, with a particular focus on mental health support for male employees.

Intervention and Rehabilitation Measures

Interventions to reduce economic uncertainty and economic risks should be a focus of future research from two aspects. Future research can be conducted around three aspects: First, to examine how to cultivate an individual's adaptive mentality to epidemics. Second, to explore individual resilience and psychological rehabilitation during and after a pandemic crisis (Hjemdal et al., 2011). Third, to explore the use of online interaction for social and mental health support. During the pandemic, providing remote mental health services is very important (Salameh et al., 2020). Future studies should examine online interactions to cultivate empathy and a sense of connection to enhance mental health (Schroeder et al., 2017; Waytz and Gray, 2018).

Consequences of Mental Health

There are currently few studies on the behavioral consequences of mental health, and more research is needed to understand the behavioral consequences of mental health caused by the epidemic. For example, the current research mainly focuses on panic buying behavior, and other compensatory behaviors can be added in the future, such as increasing the number of purchased goods, increasing specific food consumption, online shopping, and so on. Another example is to understand how individual factors (including health anxiety) specifically affect people's behavior in response to the pandemic (Asmundson and Taylor, 2020b). In addition, more research is required to examine the impact of the economic impact of the epidemic on the long-term behavior of individuals, especially stressful behaviors such as alcohol abuse, drug abuse, and suicide.

Impact of Macro-Environmental Factors

Culture

In different cultural contexts (e.g., collectivism vs. individualism), economic distress and non-interventional measures such as social distancing may have different effects on mental health. From an evolutionary psychology perspective, when a group encounters a collective threat, strict rules may help the collective to coordinate and survive (Roos et al., 2015). In the face of a pandemic, a culture that is accustomed to putting freedom above safety can make community coordination difficult. However, currently there is little comparative research on mental health and behavior changes specifically for different cultures, and it is worthy of further thinking in the future.

Ethnic Group

People of different ethnic groups may have different attitudes and behaviors toward the epidemic. Further research is needed to examine the different responses of different ethnic groups to the epidemic (Rubin et al., 2009). Moreover, ethnic groups may have different degrees of xenophobia due to fear of coronavirus, and more research is needed to understand the relationship between coronavirus phobia and coronavirus-related xenophobia, and the possible role of individual difference variables (e.g., susceptibility to disease) within an ethnic group (Taylor, 2019).

Economic Development

Future research may examine the relationships between economic development and the impact of the pandemic on mental health based on the economic status of different countries, and explore

solutions to the severe psychosocial health phenomena that may be caused by socio-economic crises in economically underdeveloped countries amid a large scale crisis.

Country

Relatively little research is focused on how psychological distress caused by the pandemic varies across countries. Future studies can compare and analyze the differences in the level of psychological distress in different countries with different economic conditions. As countries have achieved varying degrees of success in controlling the spread of the COVID-19 virus (Patel and Rietveld, 2020). Future research based on international data can further explore the level of psychological distress in countries where government interventions are relatively successful, in comparison with those countries that are not so successful.

Long-Term Effects

As the COVID-19 pandemic continues to evolve, the sources of psychological distress surrounding the pandemic and the degree of psychological distress may change (Piltch-Loeb et al., 2021). The extant research mainly focuses on the early or short-term psychological impact of the pandemic. Long-term longitudinal research should be added in the future to investigate the sources of psychological and mental distress at different time points (Magnavita et al., 2020). Although a large number of studies have found a positive relationship between the economic uncertainty (or difficulties) and mental health problems, other studies do not degree with the relationship between deteriorating mental health and the level of job insecurity and financial impact (Kwong et al., 2020). Further empirical research is needed to understand the interrelationships among various antecedents and how different factors mediate or moderate the relationship between the pandemic and mental health.

CONCLUSION

This conceptual analysis article explores two mechanisms (i.e., economic distress and employment distress) that lead to the deterioration of individuals' mental health. The proposed conceptual framework explains how the COVID-19 pandemic and public health interventions affect people's mental health, the responding coping behaviors. The extant literature provides evidence supporting the hypothesis that the COVID-19 pandemic and its associated measures increase individual economic uncertainty and employment uncertainty, thereby triggering mental health problems and coping behaviors. The findings of most studies support this mechanism from the onset of the pandemic to the emergence of economic distress and employment distress, to the deterioration of mental health, and then to changes in people's behaviors. Supportive evidence was found in different countries (e.g., the United States, China, Bangladesh, Italy, etc.) and in different groups (elderly, young, disabled, mentally ill, etc.).

AUTHOR CONTRIBUTIONS

XL: conceptualization, methodology, and writing – original draft preparation. ZL: conceptualization and writing – reviewing and editing. All authors contributed to the article and approved the submitted version.

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Global Inequality in Service Sector Development: Trend and Convergence

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The COVID-19 pandemic has caused a huge impact on global service sector. In the pandemic background, to understand the disparity in service sector outputs at the global level is crucial for assessing the effectiveness of development policies in different countries. This study investigate the global service sector and it aims to investigate the transitional dynamics of the output from the service sector by adopting stochastic kernel analyses. Distribution dynamics analyses are carried out for all the countries in the world. The data are then divided into different regional and income groups to evaluate the impacts of geographical location and income on the development of the service sector. The results show that the Global North will continue to make greater strides, while the output capacity in many Global South countries struggles to reach the global average. Moreover, it is shown that countries with higher per capita income will perform better in the development of their service sector than those with low per capita income, thereby highlighting the persistence of global inequality. Finally, this study shows that the Sub-Saharan Africa region and the South Asia region both are very important in the alleviation of global inequality.

Keywords: COVID-19 pandemic, service sector development, distribution dynamics analysis, disparity, convergence

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) continues to appear globally. As of October 08, 2021, the number of infected people globally is almost 237 million and it has caused more than 4.8 million deaths worldwide (National Health Commission [NHC], 2021). As stated by Goodell (2020), the pandemic may cause economic havoc through its heavy economic costs. COVID-19 related closures and lockdowns have a larger knock-on effect on global service sector and it is worth to investigate the disparity in service sector outputs.

Structural transformation is an integral part of the economic growth and development process. During the industrialization process, the share of agriculture in employment and output declines, and the share of manufacturing and service increases. While the manufacturing sector matures, the employment and output in the service sector continue to grow. In some highly open countries, comparative advantage is strongly concentrated in manufacturing, however, the output of manufacturing may decline due to the economy eventually rebalances in the increase in service

component (Noland et al., 2012). According to **Figures 1**, **2**, service sector output and employment share in the world average level were increased significantly during the past decades.

However, the disparity in the service sector growth in the world also increased dramatically in that period. Ogundele et al. (2020) confirmed inequality in the health care service sector in Sub-Saharan Africa. Antonelli and Tubiana (2020) found that knowledge-intensive structural change raised the levels of income inequality in 20 OECD countries from 1990 to 2016. Mehta and Hasan (2012) examined the effects of trade and service liberalization on wage inequality in India. They found that 30–66% of the increased wage inequality was due to changes in industry wage. Mookerjee and Kalipioni (2010) used a sample of developing and developed countries to study the finance service sector and income inequality. The authors concluded that barriers to bank access significantly increase income inequality. Xiao et al. (2019) examined the CO_2 emission performance of 25 Yangtze River Delta cities during 2007–2016. They found that the total factor carbon emission performance (TCPI) gap between the secondary and service industries narrowed over the study period and TCPI inequality in secondary industry was much larger than in the service industry. Some other scholars have focused on examining the convergence of the service sector. For example, Kinfemichael and Morshed (2018) examined the unconditional convergence of labor productivity in the service sector for 95 countries. Wang and Zhang (2014) examined the σ-convergence, stochastic convergence, and β-convergence of CO_2 emission in different service sub-sector in China. The authors found that per capita emission in all sectors converged across provinces from 1996 to 2010. However, most of the studies on inequality in the service sector have been based on provincial-level or single-country data, and thus the policy implications derived from these studies are valid for formulating policies at the country level and the provincial level only.

The existing literature cannot provide policy makers with relevant information on service sector inequality. This study aims to fill the gap in the literature by studying the disparity in the service sector growth on a global scale. The database used in this study is made up of countries in the world and this is the most comprehensive research ever undertaken at the global level for investigating disparity and convergence of service sector output by using distribution analysis. This is the first study to uses a new stochastic kernel approach in the transition dynamics analysis, which provides an in-depth understanding of the disparity and convergence feasibility of service sector output around the globe. Moreover, this study proposes a new analytical framework for interpreting mobility probability, which can be used in conjunction with a contour map or three-dimensional plot. The proposed new framework offers additional insights and greatly enhances the traditional distribution dynamics analysis (Quah, 1993a,b, 1996a,b,c, 1997).

In this study, the causal relationship between the impact of COVID-19 and global service sector inequality is not our priority to study and we are focused on the distribution of global service inequality. COVID-19 has spread all over the world and the social distancing rule has forced many service firms closed. This has significantly affected the global service sector and exacerbated the inequality in the service sector. A comprehensive study on the distribution of the Relative Service Value-Added per Capita (RSVAPC) of global countries provides policy makers with reliable references to improve global service sector development strategies by prioritizing supportive policies across the countries. The world organization for service development can encourage capital and technology resources directed to these lagging countries with imbalance RSVAPC. Moreover, the distribution dynamics approach would forecast the future pattern of country-level RSVAPC, this will show the United Nations and the governments an effective way to promote the rationalization of RSVAPC transition.

The rest of the paper begins with a brief review of the literature in Section "Literature Review." Section "Data and Methodology" describes the data and methodology. Section "Discussions" investigates the dynamics of the spatial distribution of RSVAPC, while Section "Conclusion and Implications" summarizes the findings and discusses the policy implications.

LITERATURE REVIEW

In fact, most of the literature on the rising size of the service sector has emphasized its growth, rather than distributional, effects (Cavelaars, 2006; Chakraborty and Nunnenkamp, 2008; Singh, 2014; Hassan and Abdullah, 2015; de Souza et al., 2016; Freytag and Fricke, 2017; Latorre et al., 2018; Omri, 2018; Basuil and Datta, 2019; Beqiraj et al., 2019; Doytch and Uctum, 2019; Morikawa, 2019; Liao, 2020). These studies all confirms that degree of competition, FDI, innovation and oil revenue is positively correlated with the growth of service sector.

However, other scholars have focused on the study of productivity in service sector. Kuijs and Wang (2006) suggests that contribution to increased service sector productivity comes from growth in capita per worker and TFP growth. Their argument is widely accepted, and many researchers suggest that fast productivity growth in the service sector contribute to the balance growth of economies (Wu, 2007; Bosworth and Collins, 2008; Miroudot et al., 2012; Nabar and Yan, 2013; Sauian et al., 2013; Tochkov and Yu, 2013; García-Pozo et al., 2018; Karim et al., 2018; Kinfemichael and Morshed, 2018; Lee and McKibbin, 2018; Zhang and Lin, 2018; Álvarez-Rodríguez et al., 2019; Haller and Lyons, 2019).

In recent decade, the relationship between CO2 emissions, energy, and the service sector has become a hot topic. Input-output approach and the data envelopment analysis (DEA) approach have been applied frequently for study the CO2 emissions and energy efficiency on service sector (Gowdy and Miller, 1987; Alcántara and Padilla, 2009; Butnar and Llop, 2011; Fang et al., 2013; Lin and Zhang, 2017; Brown et al., 2020; Hou et al., 2020; Wang et al., 2020). Some researchers have examined the energy consumption on service sector. For example, Mulder et al. (2014) analyzed the energy intensity developments across 23 service sectors in 18 OECD countries over the period 1980–2005. Tang and Shahbaz (2013) used the annual data from 1972 to 2010 to assess the causal relationship between electricity consumption and real output at the aggregate and sectoral levels in Pakistan.

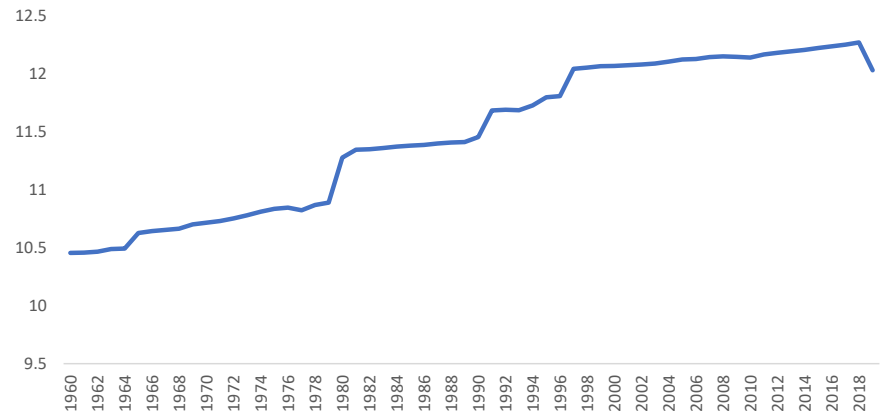

FIGURE 1 | Log service value added. Data reflect available observations from all countries for 1960–2019 and are reported in constant 2010 US $. Source: World Bank (2021).

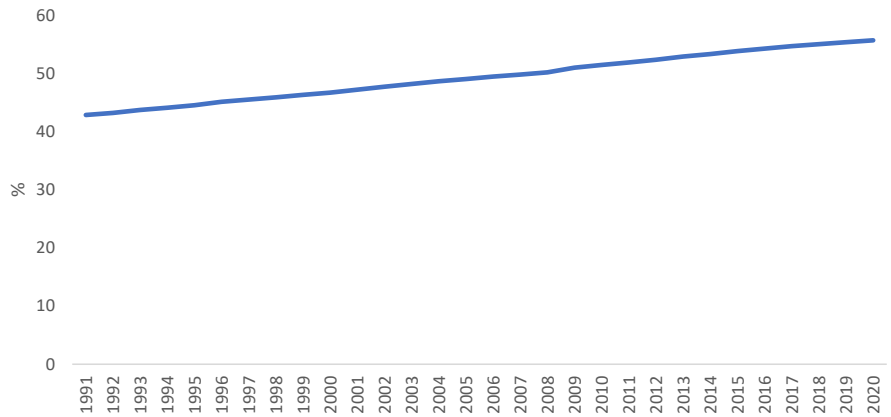

FIGURE 2 | Employment in service (% of total employment). Source: World Bank (2021).

Voulis et al. (2017) used Netherlands as the case to study the impact of the service sector on the potential for renewable resource integration in urban energy systems. Xing et al. (2018) estimated the energy demand in the Chinese service sector at the provincial level up to 2030.

In terms of methodology, due to the problems of multicollinearity, a major shortcoming is that regression models cannot include many independent variables. This would cause many other relevant factors are neglected. Also, the output of regression models is the forecasted value of the dependent variable. This cannot be used to forecast the evolution of distribution. Moreover, regression models fail to provide information on the value of the convergence and the number of convergence clubs in the distribution (Shi et al., 2020). However, this information is important for policy makers. The distribution dynamics is making no assumptions about the underlying distribution of the population and it allows us to understand the transitional dynamics of RSVAPC over time. This method could provide intra-distribution mobility for the countries. It can even offer detailed information on each spatial grouping by revealing their distinguishing features in terms of RSVAPC (Cheong et al., 2019). In addition, this approach can be used to offer a forecast for the shape of the distribution of RSVAPC in the long run, which is an issue particularly relevant from the policy implications perspective.

A noteworthy feature of this strain of research is that most of the existing studies are based on single country data or only focused on few countries and there has been no application of a global scale. In addition, the distribution dynamics approach has not been employed in service sector studies. Compare with existing convergence methods, the distribution dynamic approach does not need assumptions about the underlying distribution of the population, and it also has some advantages over the parametric methods. Thus, this paper aims to study the evolution and convergence of RSVAPC on a global scale.

DATA AND METHODOLOGY

The dataset was compiled from the World Development Indicators provided by the World Bank. The data of value-added (constant 2010 US$) of the service sector and the population

of each country were gathered first and the value-added per capita was computed accordingly. After that, the global average value of value-added per capita was derived for every year. The value of each country's value-added per capita was then divided by the global average to derive the relative service value-added per capita (RSVAPC) for this particular year for every country one by one. Almost all the countries have been included in this study although a few of them are missing due to data unavailability.

Distribution dynamics analyses were then conducted based on the RSVAPC values of each country. It is worth noting that the distribution dynamics approach was first proposed by Quah (1993a) in the 1990s. This approach focuses on the evolution of the distribution across time so that it is very useful for investigating the changes in distribution and the underlying trend behind these changes.

The distribution dynamics approach is different from the econometrics analysis which is commonly employed in research. First, econometric analysis can only offer the forecast of the value of the dependent variable which is a forecast of a point, so it is impossible to prepare a forecast of the shape of a distribution. On the contrary, distribution dynamics analysis can be used to evaluate the change in the distribution in the long run. Moreover, the probability of the movement of the entities within a distribution can also be computed by the distribution dynamics approach so pragmatic policy suggestions can be derived and the underlying trend across time can be known in detail.

The distribution dynamics analysis approach can be divided into two categories, namely, the Markov transition matrix analysis and the stochastic kernel analysis. It is noteworthy that the latter is deemed to be much better than the former because the latter is not affected by the problem of arbitrariness in grid selection, and the values of demarcation of state for the latter can be derived objectively. As a result, the stochastic kernel approach is employed in this study.

The bivariate kernel estimator can be represented by the format as shown below:

$$\hat{f}(x,y) = \frac{1}{nh_1h_2} \sum_{i=1}^{n} K\left(\frac{x - X_{i,t}}{h_1}, \frac{y - X_{i,t+1}}{h_2}\right) \quad (1)$$

where h_1 and h_2 are values of bandwidth. They are optimal bandwidths which were computed by the procedure suggested by Silverman (1986), $X_{i,t}$ is an observed value of RSVAPC at time t, x is RSVAPC at time t, $X_{i,t+1}$ is the observed value of RSVAPC at time $t+1$, y is RSVAPC at time $t+1$, K is the normal density function, and n is the total number of observations.

Given that the data of RSVAPC are not evenly distributed throughout the dataset, therefore, the number of data varies greatly across the range of RSVAPC. Many observations may congregate around some specific values of RSVAPC, whilst other values may only have a few data. This can lead to spareness in the dataset which can affect the estimation, therefore, a two-step procedure suggested by Silverman (1986) was employed to take this into consideration. In the first stage, a pilot estimate was made and the bandwidth was rescaled in the second stage based on the spareness of the data.

Assuming that the evolution of data is time-invariant and first order, the distribution dynamics can be represented by:

$$f_{t+\tau}(z) = \int_0^{\infty} g_\tau(z \mid x) f_t(x)\, dx \quad (2)$$

where $g_\tau(z \mid x)$ is the probability kernel which maps the distribution from time t to $t+\tau$, $f_{t+\tau}(z)$ is the τ-period-ahead density function of z conditional on x. and $f_t(x)$ is the kernel density function of the distribution of RSAPC at time t.

By repeated use of Eq. 2, the ergodic distribution (given that it exists) can be derived by:

$$f_\infty(z) = \int_0^{\infty} g_\tau(z \mid x) f_\infty(x)\, dx \quad (3)$$

where $f(z)$ is the ergodic density function which is the steady-state distribution in the long run.

Cheong and Wu (2018) developed the Mobility Probability Plot (MPP) for studying the probability of future movement of the entities within a distribution. This is a very useful tool and it has been applied extensively in many different fields, for example, industrial output (Cheong and Wu, 2018), carbon emissions (Cheong et al., 2016; Zhang et al., 2020), and consumption of electricity (Cheong et al., 2019).

The MPP is defined as $p(x)$ which is the net probability of moving upward for the countries within the distribution:

$$p(x) = \int_x^{\infty} g_\tau(z \mid x)\, dz - \int_0^{x} g_\tau(z \mid x)\, dz \quad (4)$$

The MPP indicates the net probability of an increase in the RSVAPC for different countries. It is denoted in percentage and the value is from -100 to 100. A negative value implies that the country has a higher tendency to move downward within the distribution in the next period, while a positive value of MPP indicates that the country has a higher tendency to move upward within the distribution.

DISCUSSION

For a long, the evolution of a country or the whole world, from agricultural to industrial and then to a service economy, seems to be a natural and inevitable process for economic development. The service sector remains a massive component of the economy in developed countries such as the United States and the United Kingdom, accounting for about 80% of GDP, as per the World Bank National Accounts Data. On the contrary, the figure declines to nearly 30% in low-income countries. Despite the difference, it is noticeable the share of this sector in both developed and developing economies is increasing with each passing year. Moreover, jobs in the service industry are expected to boost employment growth in the future; while the rate of employment in agriculture and manufacturing industries will be on a decline, according to the Kühn et al. (2018) World Employment and Social Outlook.

This section will present global development in the service sector analyzed through the distribution dynamic model. The

analyzed data can show an all-inclusive pattern of development in the service sectors of all countries across the globe. This will further reveal the disparity in the service sector growth and the viability to achieve convergence gradually. For further analysis of this critical issue in detail, the full dataset was divided into different groupings. Moreover, to ensure an in-depth analysis, all distribution dynamics analyses were performed separately for each grouping. The groupings are determined based on the Global North and Global South, levels of income, and geographical locations.

All Countries

Figure 3 demonstrates the three-dimensional kernel-based transition probability for the Relative Service Value-Added per Capita (RSVAPC) of all countries. Secondly, **Figure 4** presents a contour map along with the transition dynamics of the national units. In **Figure 3**, the relative frequency indicates the probability of transition at the country level from one particular RSVAPC value in year t to another RSVAPC value in year $t1$. It is noteworthy that the RSVAPC value is calculated based on the global average; hence, one is the average value. Consequently, a value less than one and larger than one marks a below-average and above-average RSVAPC, respectively. **Figure 3** indicates that the majority of countries had an RSVAPC value of nearly 0.1, indicating a below-average RSVAPC.

In **Figure 4**, the contour map shows a top view of the three-dimensional graph. It can be visualized that **Figure 4** could be separated into several vertical lines, with each line serving as a probability density function by itself—showing the probability of transitions from period t to period $t + 1$. For instance, when a specific country has the RSVAPC value of 0.1 at period t, a vertical line intersecting the horizontal axis at 0.1 can be imagined. The intersection points of this imaginary vertical line with the contour lines illustrate the probability of climbing from the initial level of 0.1 to other values of RSVAPC plotted on the vertical axis. It can be seen from the graph that the imaginary vertical line peaks

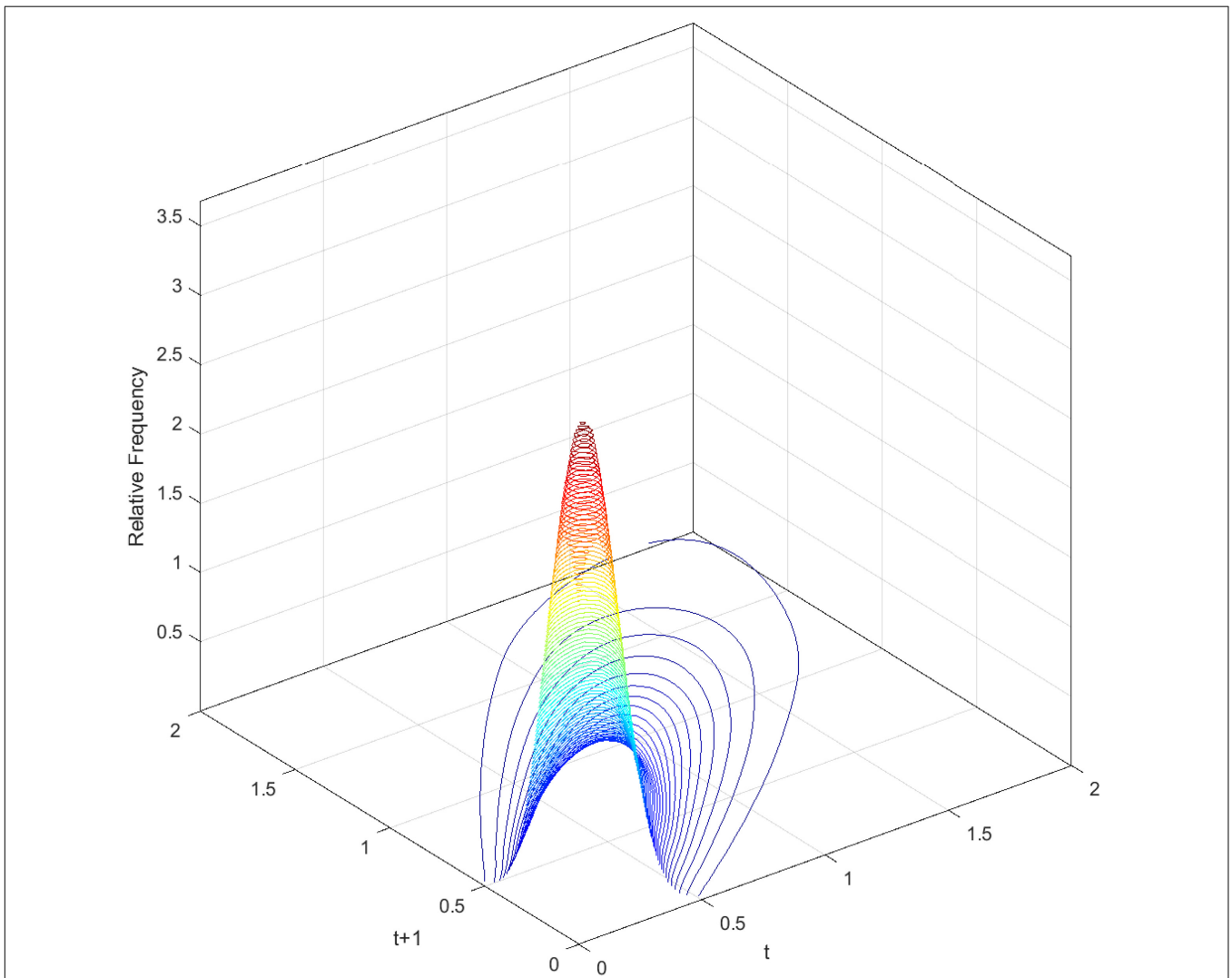

FIGURE 3 | Three-dimensional plot of transition probability kernel for the relative RSVAPC of all countries with annual transitions. Source: Authors' calculation.

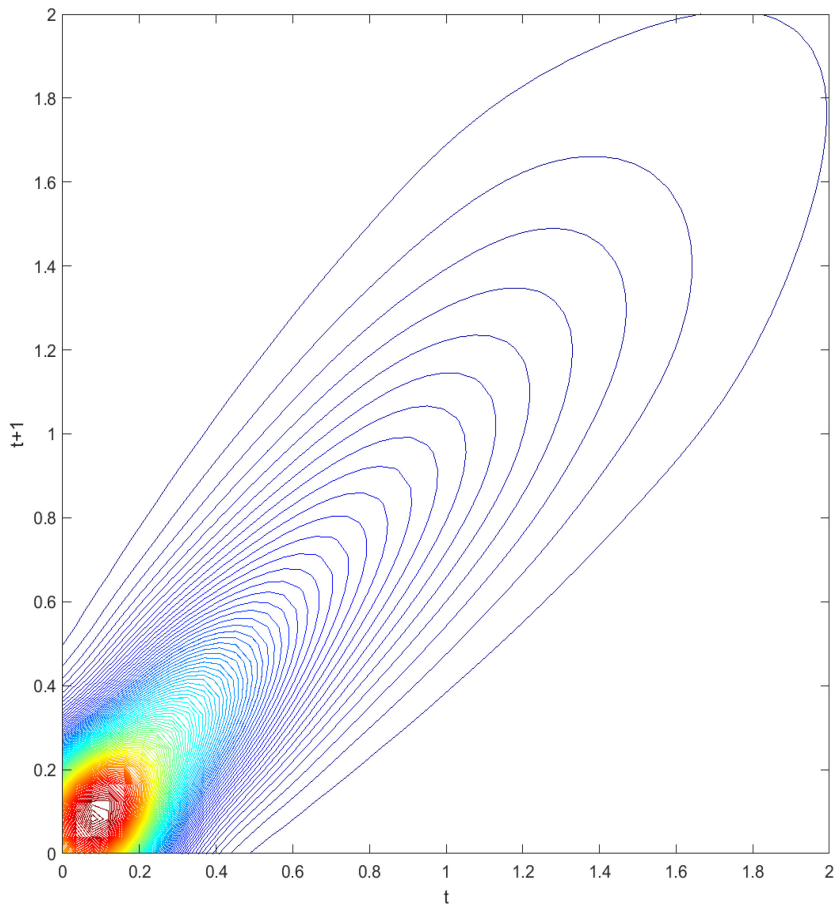

FIGURE 4 | Contour map of transition probability kernel for the RSVAPC of all countries with annual transitions. Source: Authors' calculation.

at the point where the RSVAPC value on the vertical axis is also 0.1. This indicates that a country with 0.1 as an initial value of RSVAPC will have a relatively high probability to remain at 0.1 in the following year. It can also be seen that the imaginary vertical line will reach the last contour line when the RSVAPC value on the vertical axis is equal to 0.65. This means that there is a low probability to climb from 0.1 to 0.65 and it is even lower when moving up to higher regions where contour lines are not visible.

In conclusion, the persistence is quite high, based on **Figures 3**, **4**. Evidently, as shown in **Figure 4**, there is a very high probability for the countries to remain in their current states of service output capacity. The probability mass peaks along the diagonal, thereby showing that there is a very high probability for the countries to remain at their current positions. This illustrates very slow progress in the development of the service sector. Moreover, as the variability (the probability of moving upward/downward in the next period) in probability mass is relatively low for countries with RSVAPCs less than 0.4, perseverance is observed to be more severe for countries with lower values of RSVAPC. Thus, **Figures 3**, **4** clearly show that the development of the service sector in countries with extremely low values of RSVAPC remains sluggish, thereby indicating a disparity in the development patterns of the global service sector. This is the first piece of evidence for the unbalanced and inadequate development of the concurrent service sector. The disparity and rigidity inherent in the transition dynamics in both the figures will subsequently translate into a country-level long-run steady-state distribution of RSVAPC.

Figure 5 shows the long-run steady-state ergodic distribution of the countries. As observed, several countries are likely to converge where the RSVAPC value is 0.08—the highest peak observed from the distribution. As one is the global average; industrial development in numerous countries will be very low if the transition dynamics do not change. It can also be observed that convergence club at a higher level, with a small peak where the value of RSVPAC value is 5.1. It indicates that these countries will congregate at this particular value of RSVAPC. Despite the higher values of RSVAPC as compared to the global average, the situation is unlikely to be impressive, since it suggests that many countries across the globe, with few exceptions, will incline toward low production capacity as a norm.

Considering that the service sector will fuel the future development of the service sector, the ideal overall situation to manage the issues of the low and uneven capacity of production would be a steady convergence to the global average. Eventually, countries with below-average values of RSVAPC will need to

climb upward and/or the ones with above-average values to move downward. However, countries with high production capacity should not lower their output. As a consequence, there will a strong plea of attention to countries with below-average RSVAPC values, especially those with low or no capability to move up. This study helps in identifying these countries by observing the MPP.

In **Figure 6**, the MPP plots the probability of net upward mobility, ranging from -100 to 100, as a percentage against the RSVAPC values. A positive value represents a country with a positive probability of net upward mobility, while a negative value illustrates a country with a negative probability of upward mobility. When moving from a region above the horizontal axis to the one below the horizontal axis, the MPP will intersect the horizontal axis. It is imperative to note that countries on the left-hand side of the intersection point have a positive value while the ones on the right-hand side of the intersection point have a negative value. Therefore, a large number of countries will converge around the point of intersection. Consequently, the transition dynamics underlying the MPP in **Figure 6** enable a thorough understanding of the shape of the ergodic distribution in **Figure 5**. **Figure 6** shows that the MPP intersects at the horizontal axis where the value of RSVAPC is 0.16. Subsequently, until the MPP intersects the horizontal axis again at the point where the value of RSVAPC value is 3.9, it remains negative. Therefore, within the distribution, only those countries with extremely low levels of output (RSVAPC values of less than 0.16) and extremely high levels of output (RSVAPC values of more than 3.9) showed a higher likelihood to move upward.

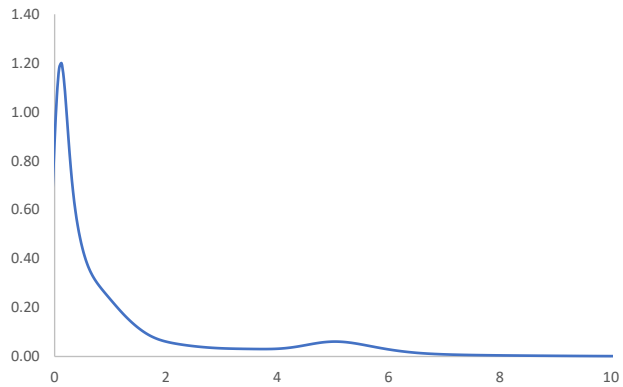

FIGURE 5 | Ergodic distribution for the relative RSVAPC of all countries with annual transitions. Source: Authors' calculation. N.B. The vertical axis indicates the density of probability and the horizontal axis indicates RSVAPC values.

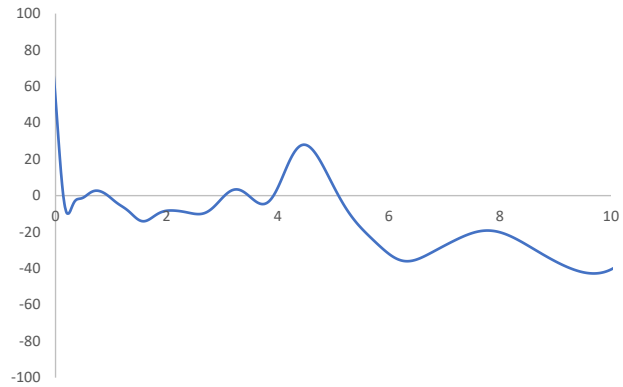

FIGURE 6 | Mobility probability plot (MPP) for the RSVAPC of all countries. Source: Authors' calculation. N.B. The vertical axis indicates net upward mobility (%) and the horizontal axis indicates RSVAPC values.

Based on this alarming result, one may think about the reason most, if not all, countries failing to make progress in their service sectors, while a few of them continue to outperform the rest. To examine the service sector growth in detail, the database is divided into the wealthier Global North and the poorer Global South.

Comparison Between the Global North and the Global South

In **Figure 7**, the three-dimensional kernel-based transition probabilities for RSVAPC of the two important regions (the Global North and the Global South) with annual transitions can be observed. Subsequently, **Figure 8** shows the corresponding contour maps.

Figure 7A illustrates two peaks, situated at RSVAPC values of 1 and 5, in the three-dimensional graph for the Global North. This suggests that for most countries of the Global North, the development in the service sector was well above the global average with a distinct group of countries experiencing five times above the average production capacity. On the other hand, **Figure 7B** demonstrates a contrasting scenario. Here, the peak is located at an extremely low value of RSVAPC—0.05, which is also far below the global average. This shows severe underdevelopment in most countries of the Global South, thereby indicating a disparity in the degree of global service development.

A larger variability (i.e., the likelihood of moving upward/downward in the following period) in the Global North as compared to the Global South can be observed in **Figures 8A,B**. Moreover, a rise in production capacity in both the Global North and the Global South leads to an increase in variability. It demonstrates that rigidity is relatively pronounced in countries with low values of RSVAPC—a key source of unbalanced development.

Figure 9 shows the transition dynamics translating into the long-run steady-state ergodic distribution. From **Figure 9A**, it can be observed that the two most obvious peaks are situated at the RSVAPC values of 1.35 and 5.18. This suggests an encouraging future development in the service sector of the Global North. Meanwhile, **Figure 9B** illustrates that the two peaks appear at RSVAPC values of 0.09 and 0.9, respectively. This finding is considered disturbing due to its demonstration that most countries of the Global South will have extremely low levels of RSVAPC relative to future development in the service sector. Moreover, the ergodic distribution is more scattered in the Global North as compared to the Global South. It indicates that countries are mostly tied and focused on the two below-the-average peaks with a few exceptions in the latter.

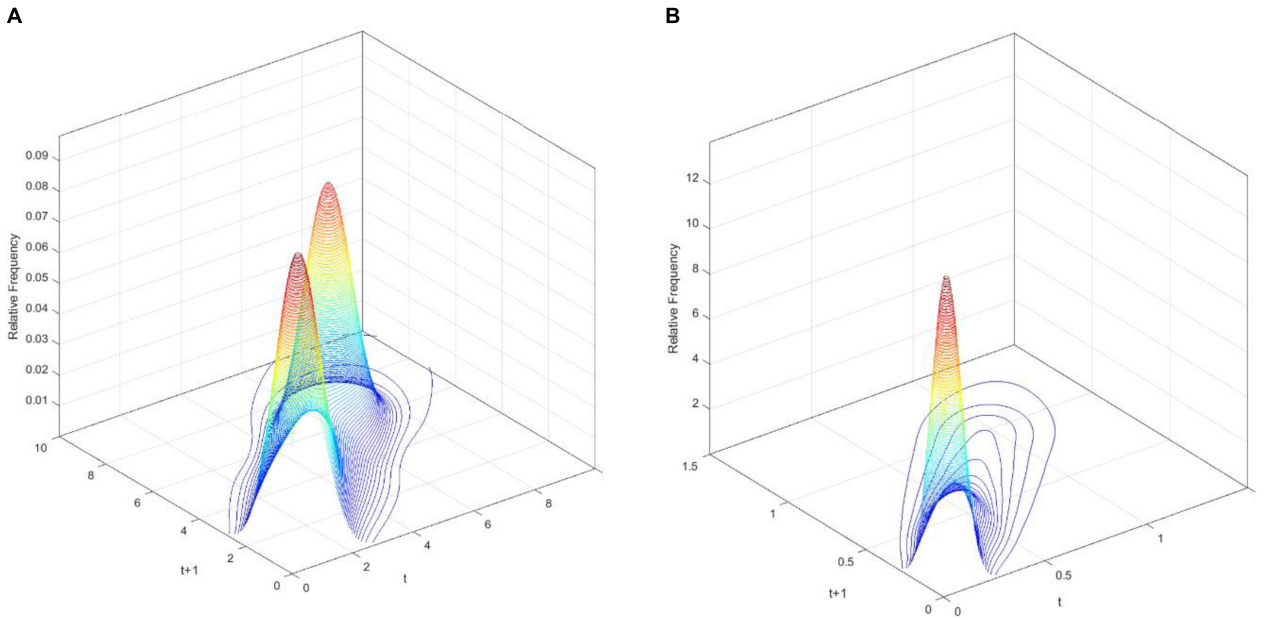

FIGURE 7 | Three-dimensional plot of transition probability kernel for the relative RSVAPC of countries for the Global North **(A)** and the Global South **(B)** with annual transitions. Source: Authors' calculation.

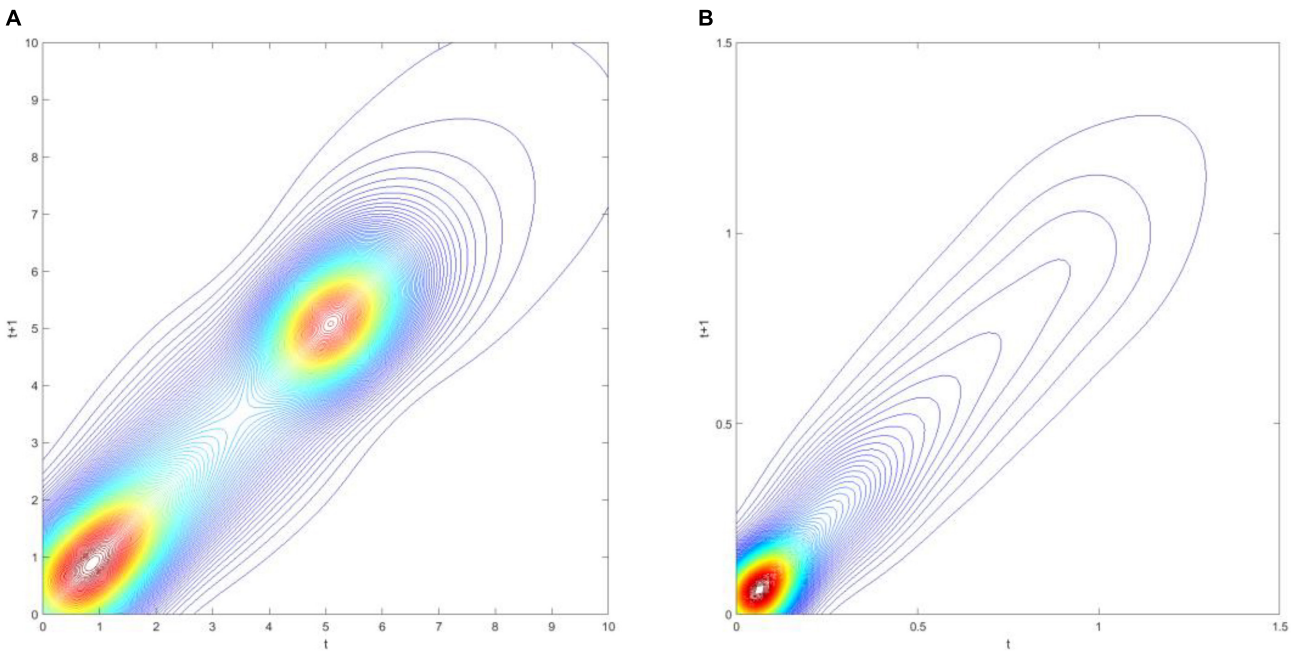

FIGURE 8 | Contour map of transition probability kernel for the RSVAPC of countries for the Global North **(A)** and the Global South **(B)** with annual transitions. Source: Authors' calculation.

In **Figure 10**, the MPP suggests a reason behind the current forms of the ergodic distributions. It can be observed from **Figure 10A** that the Global North countries with an RSVAPC value of less than 1.13 have a positive net probability of upward mobility. At this intersection, the first peak in the ergodic distribution remains evident. The second intersection point presents an RSVAPC situated at level 3.5, representing a second peak in the ergodic distribution. It is worth noting that these two peaks appear above the global average. Consequently, the MPP shows the influence of transition dynamics on a higher development in the service sector of the Global North. Conversely, in **Figure 10B**, the entire MPP appeared

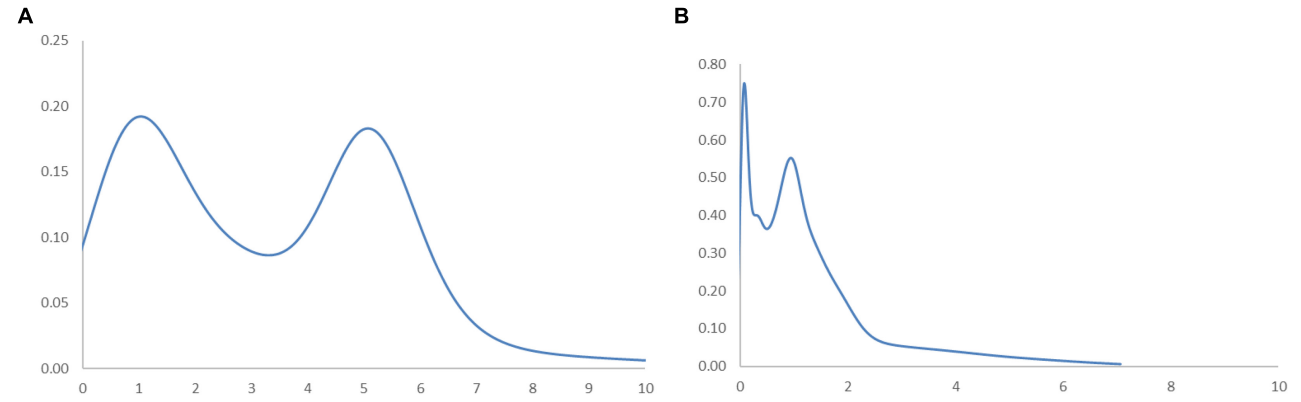

FIGURE 9 | Ergodic distributions for the RSVAPC of countries for the Global North **(A)** and the Global South **(B)** with annual transitions. Source: Authors' calculation. N.B. The vertical axis indicates the density of probability and the horizontal axis indicates RSVAPC values.

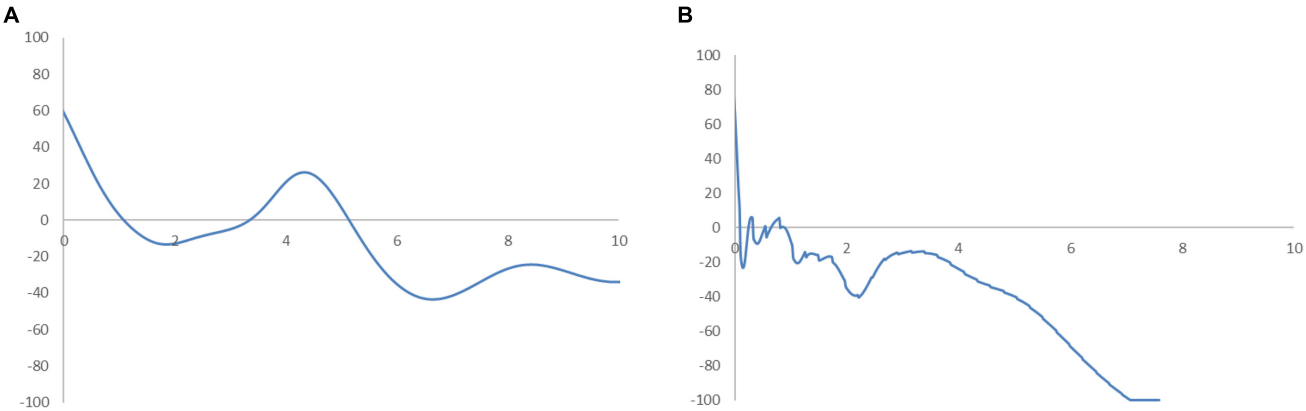

FIGURE 10 | Mobility probability plot (MPP) for the RSVAPC of countries for the Global North **(A)** and the Global South **(B)**. Source: Authors' calculation. N.B. The vertical axis indicates net upward mobility (%) and the horizontal axis indicates RSVAPC values.

almost below the horizontal axis which suggests a negative net probability of upward mobility. The first intersection point is situated where the RSVAPC value is 0.09, which is far below the former first intersection point (i.e., RSVAPC value of 1.13). It reflects that the Global South countries have relatively low service output than the global average. It is also important to note that the MPP is positive for the RSVAPC values between 0.2 and 0.9, leading to the emergence of another peak in the ergodic distribution. This is due to the presence of a few countries such as China in the Global South with a high production capacity and upward mobility. However, these exceptions are unlikely to provide any help for the development of the overall service sector in the Global South. Without such sporadic cases of countries with an RSVAPC value of less than 0.09, the entire MPP of the Global South remains below the horizontal axis. It implies that only the Global South countries with extremely low service output (those countries with an RSVAPC value less than 0.09) have a chance for upward mobility. Additionally, countries that have RSVAPCs greater than 0.09 will fail to maintain progress in their service development.

The alarming findings suggest a possibility of increasing disparity between the Global North and the Global South in the future. The development of the service sector in the Global North will continue to make greater strides, while the output capacity in many Global South countries struggles to reach the global average. This prompts the need for a re-examination of the development policy in most countries of the Global South. Moreover, the governments are required to develop pragmatic policies to address and remove a large number of obstacles (e.g., to reduce transaction costs) to the service sector development to bridge the gap between the two regions.

Comparison Between Countries Based on Income Groups (World Bank Classification)

To assess the correlation between income and industrial development without the influence of sporadic cases in the Global South, the ergodic distributions for different income groups of countries are considered. The ergodic distributions and the MPP for four respective income groups are shown in **Figures 11**, **12**.

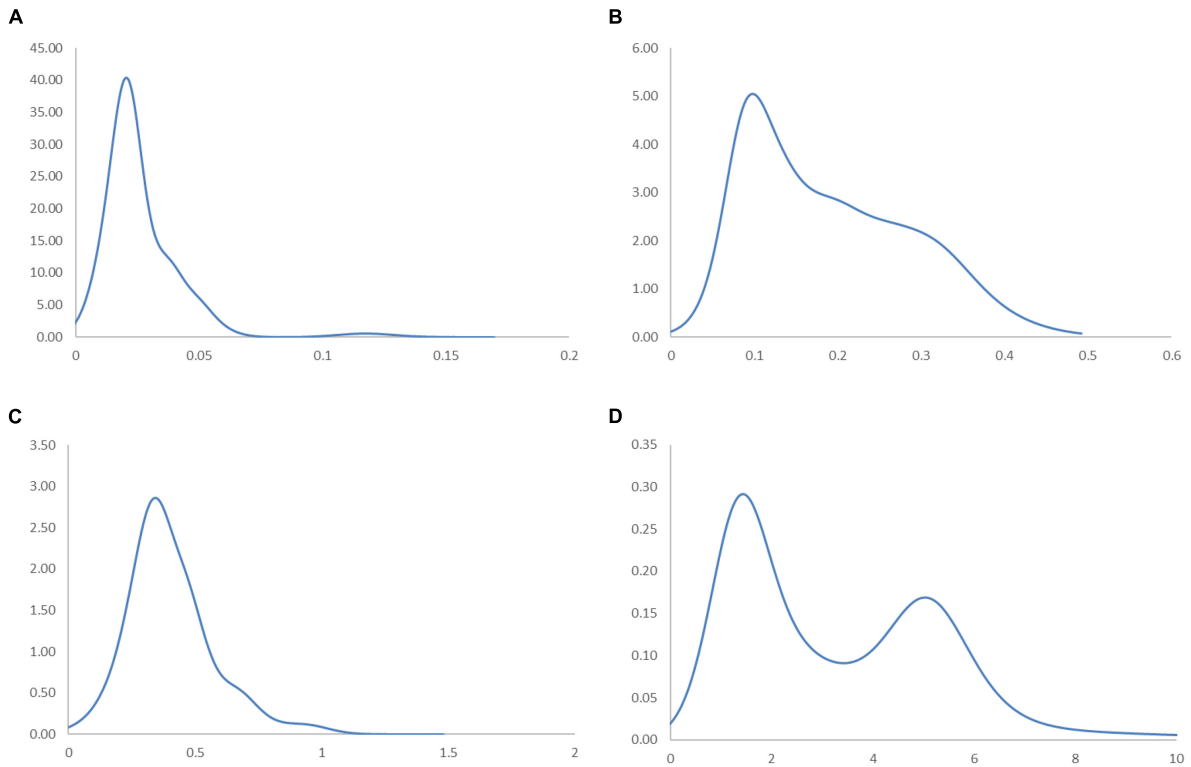

FIGURE 11 | Ergodic distributions for the RSVAPC of countries for different income groups of countries with annual transitions. Source: Authors' calculation. N.B. The vertical axis indicates the density of probability and the horizontal axis indicates RSVAPC values. **(A)** Low-income countries; **(B)** Lower-middle income countries; **(C)** Upper-middle income countries; **(D)** High-income countries.

In **Figure 11A**, the entire ergodic distribution of low-income countries is compressed to the left of the global average, with convergence clubs at the levels of 0.02, 0.04, and 0.12. Owing to the highly concentrated distribution, the peaks are visibly pronounced, and the convergence clubs are closely situated. In **Figure 12A**, the MPP for the low-income countries indicates that countries have the chance to move upward, only when the values of RSVAPC are less than 0.02, between 0.03 and 0.05, and between 0.08 and 0.12. When the RSVAPC value reaches 0.17, the net probability of upward mobility is at -100. Accordingly, low-income countries are unable to transit through the threshold where the RSVAPC value is 0.17. Upon reaching this threshold, a level less than half of the global average, the RSVAPC value of the country will decline, thereby moving it downward in the distribution. This suggests the possibility of a service development trap in low-income countries. It is an alarming situation, as development in the service sector is the future growth engine in both developed and developing countries. For low-income countries, development in the service sector is the major pathway to achieve a reasonable living standard in the future. These study findings imply that a country continues to face poverty if it exists unless there is external interference.

Figure 11B shows the ergodic distribution for the lower-middle-income countries. The distribution is more dispersed than that of low-income countries, where all the convergence clubs—0.1, 0.22, and 0.31—are below the global average. This shows that the development of the service sector in lower-middle-income countries is far from encouraging. In **Figure 12B**, the MPP confirms the implications of the ergodic distribution for the lower-middle-income countries. The first intersection point appears where the level of RSVAPC is very low at 0.1. The second and the third range of positive net upward mobility appear where the levels of RSVAPC are approximately 0.15–0.22 and 0.23–0.31, respectively. When the value of RSVAPC reaches 0.5, the net probability of upward mobility becomes -100. In other words, the lower-middle-income countries with no or relatively low levels of service output have a better chance of making proper progress in service development. However, if the output level is close to one-third of the global average (i.e., an RSVAPC level of 0.31), they struggle to maintain progress in their development. Moreover, when the level of RSVAPC for lower-middle-income countries is 0.5, the net upward mobility reaches -100. It suggests that a decline in an RSVAPC level of a country to 0.5, will bring the mobility downward in the distribution. Although a negative net upward mobility appears at a higher output level in low-income countries, a development trap in lower-middle-income countries can be found. After attaining a slightly higher level of economic growth, these countries fail to continue making further progress in development required for sustainable growth.

In upper-middle-income countries, the situation appears to be better. **Figure 11C** shows three convergence clubs. The first two peaks are below the global average at 0.37 and 0.7,

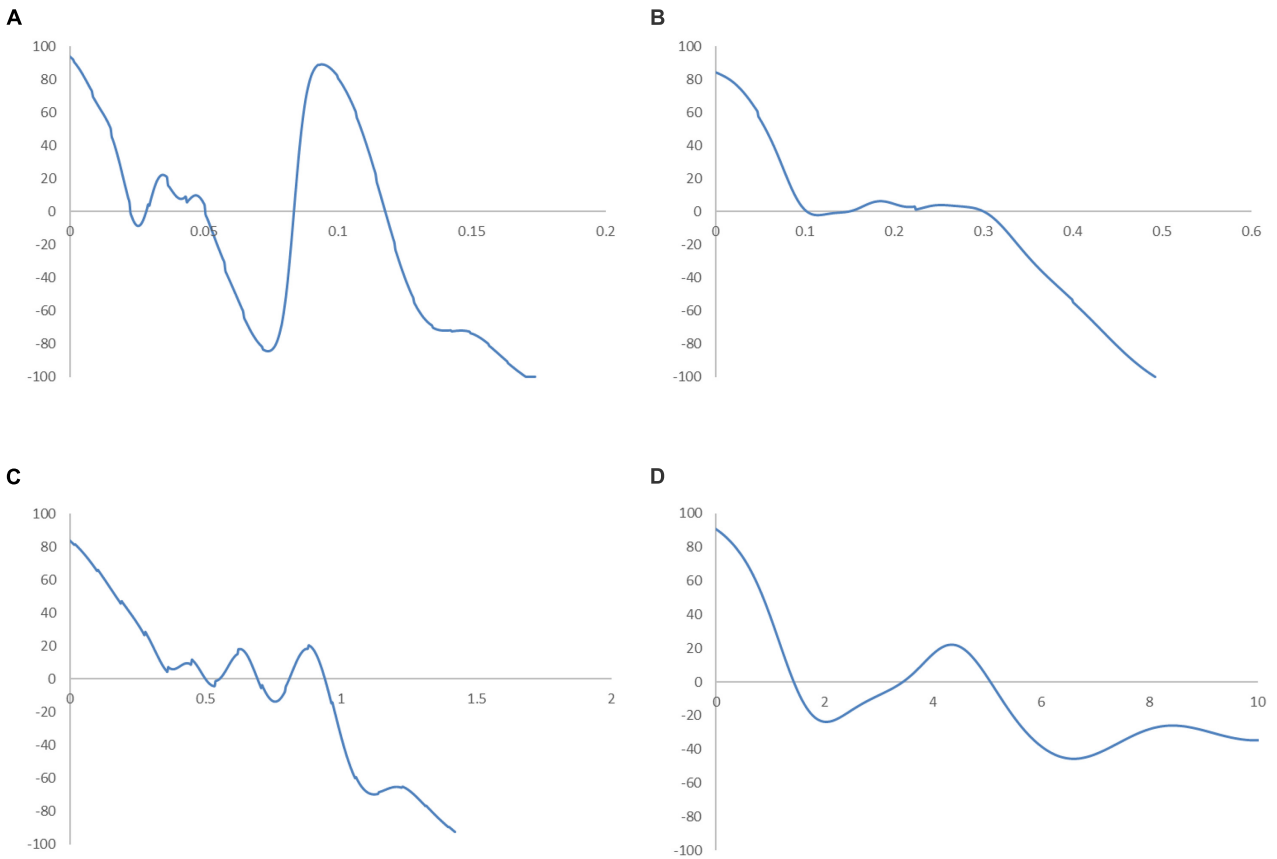

FIGURE 12 | Mobility probability plot (MPP) for the RSVAPC of countries for different income groups of countries. Source: Authors' calculation. N.B. The vertical axis indicates net upward mobility (%) and the horizontal axis indicates RSVAPC values. **(A)** Low-income countries; **(B)** Lower-middle income countries; **(C)** Upper-middle income countries; **(D)** High-income countries.

respectively. However, the third peak appears at level 0.98, which is close to the global average. Despite its similarity with the low-income and lower-middle-income countries, the overall shape of the ergodic distribution for the upper-middle countries is not comparable with the previous two distributions, as it is more dispersed and has a higher average level of RSVAPC. In **Figure 12C**, the MPP for the upper-middle-income countries shows a positive net upward mobility for RSVAPC values ranging from 0.8 to 0.95. It suggests some upper-middle-income countries with RSVAPC values around the global average can maintain sustainable development. However, the net upward mobility becomes -100 when the value of RSVAPC reaches 1.45. To avoid the development trap, the upper-middle-income countries are required to reach and sustain a high rate of development.

In **Figure 11D**, the first peak of the ergodic distribution for high-income countries is situated at the RSVAPC level of 1.7, while the second peak is situated at 5.2. Looking at this distribution, many high-income countries will have industrial development above the global average. Moreover, some of the countries even have five times the production capacity of the rest of the world. The MPP in **Figure 12D** shows that the first intersection point appears when the level RSVAPC level is at 1.5, while the second intersection point appears when the level of RSVAPC level is at 3.5. These two intersection points provide the two convergence clubs situated in the ergodic distribution. Unlike the previous MPPs for the three different income groups, there is no obvious development trap within the high-income countries. The most negative net upward mobility is about -50 when the level of RSVAPC reaches 6.7.

In the conclusion of the comparison based on four different income groups, countries with higher per capita income will perform better in the development of their service sector than those with low per capita income. Based on the distribution dynamic analysis, the growth of the service sector is linked with per capita income, thereby creating demand for services within the market. More importantly, based on the ergodic distribution and the MPP analysis, various underdeveloped countries lack the ability for upward mobility in the distribution without any external interferences. Therefore, it is not a natural and inevitable process for a specific country to evolve from agricultural to industrial and then to a service economy.

Comparison Between Regions

Figures 13, **14** illustrate regional ergodic distributions and MPP, respectively. There are similarities between the ergodic distributions for the East Asia and Pacific region, the Europe and

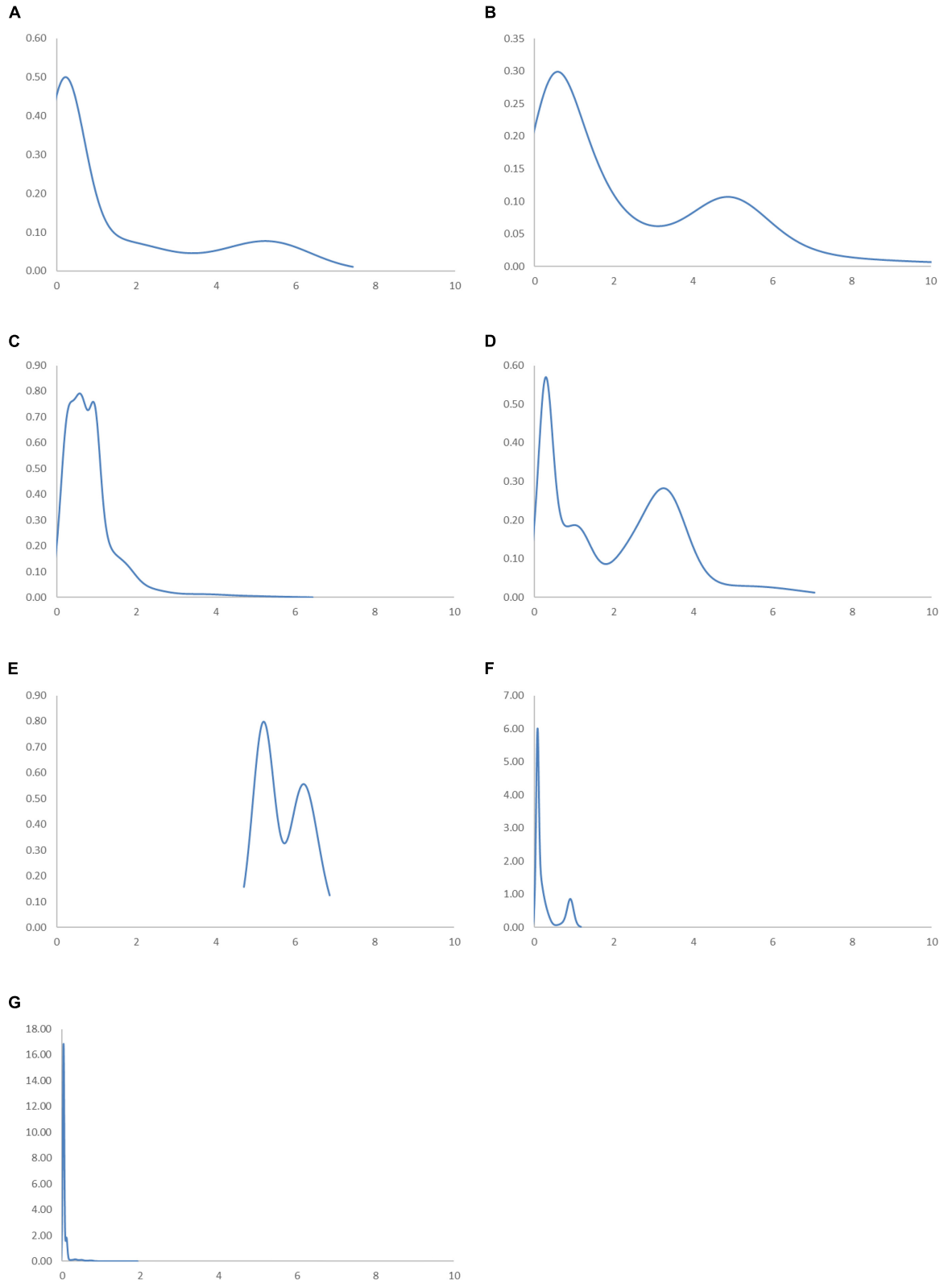

FIGURE 13 | Ergodic distributions for the RSVAPC of countries for different geographical regions with annual transitions. Source: Authors' calculation. N.B. The vertical axis indicates the density of probability and the horizontal axis indicates RSVAPC values. **(A)** East Asia and Pacific; **(B)** Europe and Central Asia; **(C)** Latin America and the Caribbean; **(D)** The Middle East and North Africa; **(E)** North America; **(F)** South Asia; **(G)** Sub-Saharan Africa.

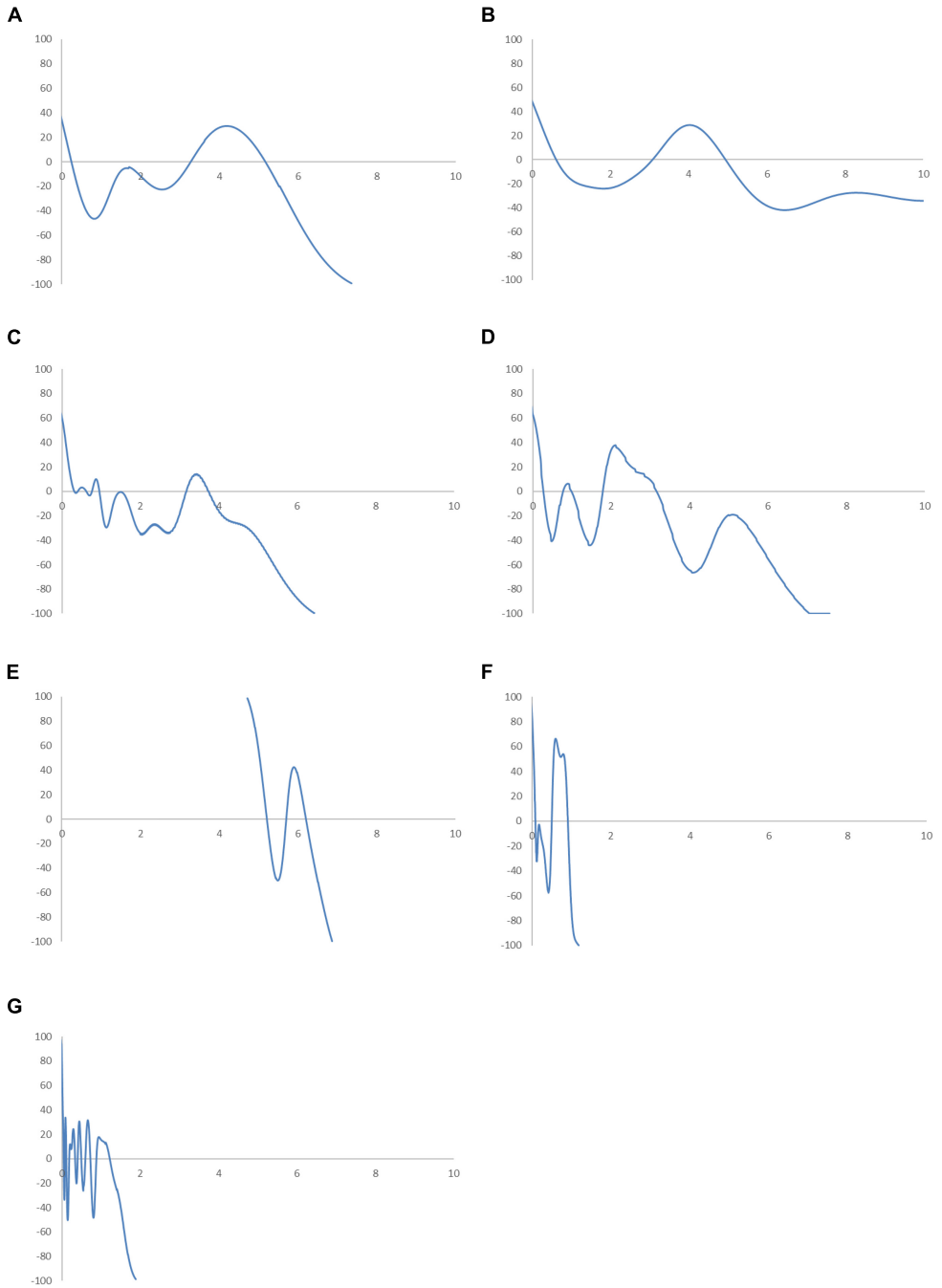

FIGURE 14 | Mobility probability plot (MPP) for the RSVAPC of countries for different geographical regions. Source: Authors' calculation. N.B. The vertical axis indicates net upward mobility (%) and the horizontal axis indicates RSVAPC values. **(A)** East Asia and Pacific; **(B)** Europe and Central Asia; **(C)** Latin America and the Caribbean; **(D)** The Middle East and North Africa; **(E)** North America; **(F)** South Asia; **(G)** Sub-Saharan Africa.

Central Asia region, the Latin America and Caribbean region, and the Middle East and North Africa region. From the ergodic distributions for these four regions, it can be observed that numerous countries cluster around the levels of RSVAPC which is less than half of the global average, while a few countries cluster around the levels of RSVAPC above the global average. For these regions, the MPP confirms the implications of their ergodic distribution. The MPP of these regions shows that the first intersection points are situated below one-half of the global average. Additionally, they have some positive net mobility when they reach a higher level of RSVAPC.

The progress of development remains the lowest in two particular regions—the Sub-Saharan Africa region and the South Asia region. For these regions, the ergodic distributions are far

below the RSVAPC value of 2. Moreover, the ergodic distribution for the Sub-Saharan Africa region is the most compact, indicating the two pronounced peaks at levels 0.02 and 0.12, respectively. In the South Asia region, the two peaks are slightly higher—0.08 and 0.95—as compared to that of the Sub-Saharan Africa region. However, when the value of RSVAPC value reaches 1.87 in the Sub-Saharan Africa region and 1.17 in the South Asia region, the net upward mobility value becomes -100. It implies that despite slightly better development progress in the South Asia region as compared to the Sub-Saharan Africa region, the former will encounter a development trap with a lower value of RSVAPC.

Compared to all the regions, North America has a relatively unique ergodic distribution and MPP. For this region, the ergodic distribution appears above an RSVAPC value of 4.7 and the first intersection point for the MPP is situated at 5.2. Moreover, it is the only region where the RSVAPC of all countries is above the global average. It is worth noting that the region will face from development trap. The net upward mobility reaches -100 in the North America region when the value of RSVAPC reaches 6.8. While the development traps in the Sub-Saharan Africa region create a hindrance in service development, the development trap in the North American region will delay development breakthroughs of the service sector across the world.

Based on the regional evidence, the primary peaks of the ergodic distributions for most regions are far below the global average, except North America. This indicates that almost all regions will not attain convergence to the global mean. The convergence clubs in all regions suggest that the unequal industrial development at the regional level is universal. The focus must be placed on the removal of upward-moving obstacles for countries that have a low level of RSVAPC and negative net upward mobility.

CONCLUSION AND IMPLICATIONS

This paper aims to examine the transitional dynamics of the globe's service output by using a new framework of distribution dynamics analysis, namely, the mobility probability plot (MPP). It is the first study to investigate the convergence and dynamics of service value-added per capita in the world. With the consideration of heterogeneity in service value-added per capita, the results are useful to policy makers in identifying the key groups for priority interventions.

It was found that, in the all-countries analysis, only those countries with extremely low levels of output (RSVAPC values of less than 0.16) and extremely high levels of output (RSVAPC values of more than 3.9) showed a higher likelihood to move upward. For the comparison between the Global North and the Global South, it was found that the development of the service sector in the Global North will continue to make greater strides, while the output capacity in many Global South countries struggles to reach the global average. However, for the comparison based on four different income groups, it was found that countries with higher per capita income will perform better in the development of their service sector than those with low per capita income. Finally, this study shows that the Sub-Saharan Africa region and the South Asia region are both very important in the alleviation of global inequality.

The COVID-19 could exacerbated the inequality in service sector in the future compare with the general situation. Based on this situation, the following policy implications can be drawn based on the empirical findings: first, policy makers need to pay more attention to the countries that have an RSVAPC level below the global average. Service development planning and policy measures need to be implemented for the countries have low RSVAPC level. Second, the global north countries should help the global south countries to achieve more balanced and inclusive growth for the service sector so as to meet the United Nations' sustainable development goals. Finally, more support should be provided to those underdeveloped countries (especially for those located in Sub-Saharan Africa and the South Asia regions) in a more targeted manner through technical cooperation with developed countries.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://databank.worldbank.org/reports.aspx?source=global-financial-development&Type=METADATA&preview=on#.

AUTHOR CONTRIBUTIONS

NM, WS, and TC: conceptualization, data curation, methodology, software, visualization, writing — original draft preparation, and writing — review and editing. TH: conceptualization, project administration, data curation, writing — original draft preparation, and writing — review and editing. All authors contributed to the article and approved the submitted version.

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The Evolutionary Trend of Global Inequality: Analyzing the Impacts of Economic Structure

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The aim of this study is to examine the evolution of inequality by focusing on the impacts of the economic structure. The technique of decomposition by income sources is employed to evaluate the contribution of the three major sectors, namely the agricultural, industrial, and service sectors to overall inequality. The data cover almost all the countries in the world from 2001 to 2017 for a total of 18 years. There are four stages of analysis in this study. The first stage of study is to provide an overall view of the evolutionary trend of global inequality, the second stage focuses on the North-South divide, the third stage determines the impacts of income groups, and the fourth stage investigates the impacts for each region. There are several salient findings: First, global inequality had declined in the study period. Second, the service sector is identified as the largest contributor to global inequality, followed by the industrial sector, while the contribution of the agricultural sector is negligible. For the North-South divide, disparity in the service sector was more marked in the North than in the South. The industrial sector played a major role in the South and contributed more than 40% to overall inequality. For the comparison amongst the income groups, our findings show that the higher the income, the higher the percentage contribution of the service sector (except for the low-income group). Finally, for the comparison across regions, although the contribution of the agricultural sector in most regions are below 1.5%; however, the contribution of the agricultural sector in both Sub-Saharan Africa and South Asia is more than 8%. It implies that a lot of people in these regions still rely on the agricultural sector for a living, and the development in the industrial and service sectors in these two regions lagged behind those of the other regions. Our analysis show that the evolution pattern is very different for each region, therefore, it is necessary to take the effects of income and geographical location into consideration in formulating development policies.

Keywords: inequality, global, decomposition analysis, economic structure, Gini coefficient

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INTRODUCTION

The General Assembly of the UN adopted the resolution for a new set of Sustainable Development Goals on 25 September 2015. Including 17 Sustainable Development Goals (SDGs) and 169 targets, the 2030 Agenda is unprecedentedly ambitious, universal and overarching. At the core of the Agenda is the determination to eradicate poverty and hunger in all their forms, which is within

the reach of this generation for the first time in human history (Hong, 2016). The changes in UN's agenda call for a detailed research on the thorny issue of inequality so that policy implications can be drawn to assist countries in formulating inequality-alleviating policies. As global inequality was integrated into the new agenda, it marks the start of a new era following the conclusion of the Millennium Development Goals (MDGs). This calls for a comprehensive research on this area so that policy implications can be drawn to assist the attempt of mitigating international income inequality.

The aim of this study is to examine the evolutionary trend of international income inequality. Given that inequality can exert various adverse impacts on society and regional stability, the United Nations (UN) integrated the issue of inequality into the new set of Sustainable Development Goals (SDGs) in 2015. The new agenda formulated by the UN provides an outline of the roadmap of human development up to 2030, and the UN expects that the new goals and targets will stimulate global action in the years ahead. This study aims to provide relevant information and policy suggestions concerning international income inequality so as to contribute to the literature in the post-MDGs era by employing decomposition analysis and studying the underlying transitional dynamics behind the trend.

This paper is divided into two research components. First, Gini indices are computed for the world to provide an overview of the evolutionary patterns and trends of international inequality. Second, the technique of decomposition by income sources is employed to evaluate the contributions of the three economic sectors. The information on the relative significances of the agricultural, industrial and service sectors can facilitate the formulation of industrial policy for economic development in the developing countries. The decomposition analysis not only can shed light on the underlying patterns of inequality, but also reveal the relationship between geographical groupings and inequality, thereby pinpointing the crux of the problem of inequality in full detail.

The remainder of this paper is organized as follows. Section 2 provides a literature review on international income inequality. Section 3 offers relevant information on methodology and the data employed in this study. Results and discussions are provided in Section 4, while Section 5 summarizes the research findings with policy implications.

LITERATURE REVIEW

Inequality has been identified as the root cause of social and political instability in many countries (Muller and Seligson, 1987; Alesina and Perotti, 1996; Wang and Hu, 1999; Acemoglu and Robinson, 2001; Wen, 2007; Dutt and Mitra, 2008; Wilkinson and Pickett, 2009; Knight, 2013). In a report prepared by the World Economic Forum (2012), the researcher sternly warned that, "... when ambitious and industrious young people start to feel that, no matter how hard they work, their prospects are constrained, then feelings of powerlessness, disconnectedness and disengagement can take root. The social unrest that occurred in 2011, from the United States to the Middle East, demonstrated how governments everywhere need to address the causes of discontent before it becomes a violent, destabilizing force." Actually, not only the United States and the Middle East countries were affected; on the other side of the globe, many western countries also suffer from similar issues as the levels of inequality have increased substantially. Many countries are troubled by inequality, and public discontent with the governments in these countries remained at a high level. It is not surprising that the researcher claimed that the rising inequality was one of the top "global risks" of the world (World Economic Forum, 2012).

Income inequality is relatively stable within countries but varies significantly among countries (Li et al., 1998; Goesling, 2001; Frazer, 2006; Acemoglu and Dell, 2010). Regarding the level of income inequality, Anand and Segal (2008) reviewed literature in the 1990s and concluded that the Gini coefficient was between 0.63 and 0.69 at that time. It is worth noting that "the concentration of world income in the wealthiest quintile (fifth) of the world's population is indeed shocking and cannot meet any plausible test of legitimacy" (Wade, 2001). However, global inequality tends to decline due to the economic rise of China and south Asian countries' industrialization (Firebaugh and Goesling, 2004; Ferreira and Ravallion, 2008; Hung and Kucinskas, 2011).

Specifically, from 1820s to 1950s there was a co-movement of per capita income and increasing global inequality, which remained more stable afterward with a unimodal distribution in the nineteenth century and between 1980 and 2000; but the pattern had become more bimodal between 1910s and 1970s (Van Zanden et al., 2014). Korzeniewicz and Moran (1997) maintained that cross country inequality is the most significant component of overall world income inequality from 1965 to 1992. Similarly, Sala-i-Martin (2002) found a reduction in the global income inequality from 1980 to 1998, and most of the global disparities can be attributed to across country rather than within country inequalities (Firebaugh, 2000). However, this declining trend may be diverted again if developing countries do not start growing (Sala-i-Martin, 2002; Jensen and Rosas, 2007; Meschi and Vivarelli, 2009; Gasparini et al., 2011; Fosu, 2017). Milanovic (2012) found similar declining trend of global income inequality, however, he claimed that the main driving factor to sustain the trend is mean income convergence which can reduce the huge citizenship premium of the rich countries. Lakner and Milanovic (2013) found that the global Gini Coefficient had dropped by two points from 1988 to 2008. Rougoor and Van Marrewijk (2015) projected that global income inequality will enlarge due to the differences in population growth and population structure across countries. The differences in the decomposition of global income inequality may be due to how cross country income comparisons are made (Dowrick and Akmal, 2005; Fosu, 2010; Ortiz and Cummins, 2011); or the quality of the database (Deininger and Squire, 1996; Chotikapanich et al., 1997; Atkinson and Brandolini, 2001; Babones and Alvarez-Rivadulla, 2007; Solt, 2009, 2016; Jenkins, 2015; Alvaredo et al., 2017). Other related issues in the time of pandemic are policy uncertainty and globalization. Fang et al. (2021) found that policy uncertainty is correlated with economic globalization negatively. Given that globalization is an important driving factor

behind the economic structure, policy uncertainty may also affect inequality. Chen et al. (2021) suggested that the World Pandemic Discussion Index (WPDI) is positively associated with income inequality in 34 OECD economies but negatively associated with income inequality in non-OECD economies, thereby suggesting that global inequality may deteriorate further with the pandemic, thereby calling for an investigation into the evolution of global inequality.

Many researchers maintain that inequality exerts an adverse effect on poverty reduction (Wade, 2004; Rupasingha and Goetz, 2007; Zhuang, 2008; Fosu, 2009; Corak, 2013); while other researchers claim that inequality has a negative impact on economic growth and financial stability (Chase-Dunn, 1975; Alesina and Rodrik, 1994; Persson and Tabellini, 1994; Alesina and Perotti, 1996; Deininger and Squire, 1998; Mahler, 2004; Huang et al., 2009; Helpman et al., 2010; Lysandrou, 2011; Van Treeck and Sturn, 2012). Cheong and Wu (2015) reported that there is a positive correlation between inequality and the crime rate. Likewise, other researchers found that inequality can lead to various types of social dysfunction, including social unrest, mental illness, racism, and even political upheaval (Muller and Seligson, 1987; London and Robinson, 1989; Alesina and Perotti, 1996; Wang and Hu, 1999; Acemoglu and Robinson, 2001; Kentor, 2001; Mahler, 2004; Wen, 2007; Dutt and Mitra, 2008; Wilkinson and Pickett, 2009; Knight, 2013). Given that income inequality has so many adverse impacts, a comprehensive study on inequality is justified so that policies can be formulated to alleviate inequality and ameliorate these adverse effects. However, to our knowledge, no recent study has been conducted on the contributions of income sources to overall global income inequality. Therefore, this study aims to fill the gap in the literature by investigating the trend of global inequality through a series of decomposition so as to reveal the relationship between economic structure and global income inequality.

METHODOLOGY AND DATA

Inequality Measurement

A lot of inequality measurements are available; however, the most common ones are the Gini coefficient because it satisfies the property of the Pigou-Dalton condition and income-zero-homogeneity (Bourguignon, 1979). The Pigou–Dalton principle suggests that a transfer of income from the rich to the poor should result in a fall of the inequality indicator, so long as the transfer does not reverse the ranking of the rich and the poor in the income distribution (Cheong, 2012). Income-zero-homogeneity means that the value of the inequality measurement should remain constant for a scale change of the whole income distribution (Cheong, 2012).

The Gini coefficient is based on the Lorenz curve, which plots the cumulative share of income against the cumulative share of population from the lowest to highest incomes. The Gini coefficient is the ratio of the area that lies between the uniform distribution line and the Lorenz curve over the total area under the uniform distribution line. The value of the Gini coefficient ranges from zero to one. The value of one corresponds to perfect income inequality, whilst the value of zero corresponds to perfect income equality.

The formulae of population-weighted Gini coefficient is

$$\sum_i \sum_j \frac{|y_i - y_j|}{2\mu} \frac{n_i}{N} \frac{n_j}{N} \tag{1}$$

where N is total population in the world, n_i and n_j are population in country i and country j, respectively, y_i and y_j are GDP per capita in country i and country j, respectively, and

$$\mu = \sum_i \frac{y_i n_i}{N} (Tsui, 1996)$$

The formula of the unweighted Gini coefficient is

$$\sum_i \sum_j \frac{|Y_i - Y_j|}{2\mu R^2} \tag{2}$$

where R is total number of countries, Y_i and Y_j are GDP in country i and country j, respectively, and $\mu = \sum_i \frac{Y_i}{R}$.

Decomposition by Income Sources

The approach of decomposition by income sources is employed in this study as it has many advantages. First, this approach can decompose Gini coefficient completely, and Gini coefficient is deemed to be the most common inequality measurement used in the literature, thereby facilitating comparisons amongst different studies. Second, the contributions of all the three major industries can be derived, therefore, it can highlight the importance of each industry and unveil the relationship between inequality and economic structure. Third, by conducting decomposition by income sources across time, the trend and evolution of inequality due to changes in economic structure can be examined in full detail.

A country's GDP is made up of the value added generated from the three economic sectors. The Gini coefficient can be decomposed into these income sources so as to calculate the contribution of each sector to overall international inequality.

$$G = \sum_{s=1}^{S} W_s Cs \tag{3}$$

where G is international income inequality as measured by the Gini coefficient, C_s is the concentration coefficients of sector s, and W_s is the income share of sector s in total income.

So G is the weighted sum of concentration coefficients which can be computed by:

$$C_s = 1 - \sum_{j=1}^{m} P_j (2Q_{sj} - W_{sj}) \tag{4}$$

where $Q_{sj} = \sum_{l=1}^{j} W_{sl}$, W_{sj} is the share of income for country j in total source income s, and P_j is the population share in total population for country j. Both P_j and W_{sj} should be sorted in ascending order of total income per capita in the calculation of C_s. The contribution of each sector can be calculated as:

$$\text{Contribution of sector } s = \frac{W_s C_s}{G} \tag{5}$$

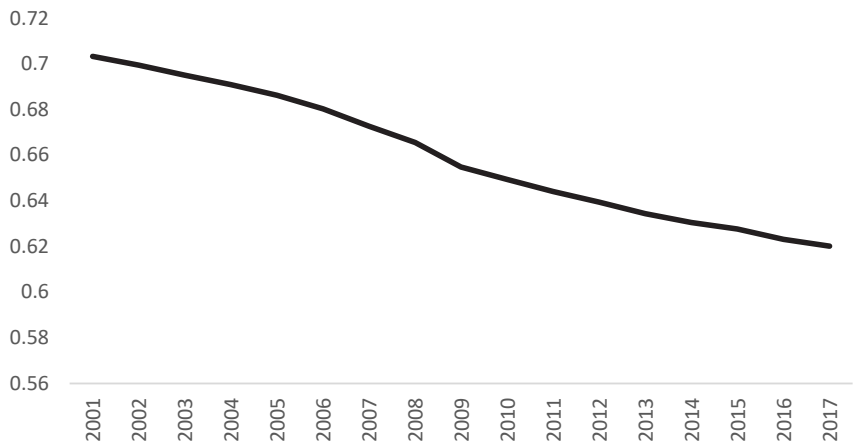

FIGURE 1 | Gini coefficient for the world, 2001 to 2017. Source: Authors' calculation.

Data

The output value of the three sectors, namely, the agricultural, industrial and service sectors, as well as the data of GDP and population were compiled from the World Development Indicator Database of the World Bank. It is notable that it is necessary to employ the same countries for calculating the Gini coefficient for every year because the addition or omission of a country in a particular year may distort the relative importance of other countries in that year. Therefore, the countries employed in this study are the same for every year in the study period. Except the value of GDP, the output value generated by each sector should also be employed in the computation of the relative contribution to global inequality, therefore, a few countries are not included in this study because of the output value of the three sectors are not available. However, almost all the countries listed in the World Bank World Development Indicators Database are included in this study. It is worth noting that it is important to maintain the same set of countries in the study period to ensure that the changes in inequality are due to the changes in GDP per capita rather than a change in the composition of the countries. Since some data are missing in later years, the study period spans from 2001 to 2017 for 17 years.

This study is divided into several stages: First, the Gini coefficient was calculated for the full dataset so as to offer an overhead view of the evolution of inequality from 2001 to 2017. Then the data were divided into two smaller datasets, namely, the North and South groups so as to examine the North-South divide. In the third stage of analysis, the dataset were separated into four income groups. The grouping method is based on the four income groups as defined by the World Bank, namely, low, lower-middle, upper-middle, and high income groups. Finally, the full dataset were divided into six regional groups according to the regional classification proposed by the World Bank, namely, the East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, South Asia, and Sub-Saharan Africa. This classification allows one to evaluate the impact of industrial policy on inequality within these regional groups. However, it is worth noting that the North America region is excluded from this study because decomposition cannot be performed satisfactorily since the number of countries in this region is too few. In fact, there are only three countries located in North America, namely, Canada, the United States, and Mexico.

RESULTS AND DISCUSSION

Global Inequality

Figure 1 shows the evolutionary trend of the Gini coefficient for all the countries in the world from 2001 to 2017. It can be observed that the Gini coefficient had dropped from 0.70 to 0.62 for an 11.8% change in this study period. This is an encouraging finding as it implies that the disparity amongst the countries had narrowed steadily across time. This is a good beginning for the implementation of the SDGs, and it sets the stage for future international cooperation in mitigating inequality.

Decomposition by income sources was then performed to evaluate the contribution of each sector to overall inequality. The results are shown in **Figure 2**. The percentage contribution of both the agricultural and industrial sectors had dropped slightly, and the service sector had increased a little. Surprisingly, it shows that the percentage contribution of each sector is fairly constant across time. 72.4% of global inequality can be explained by the disparity within the service sector, 26.4% can be explained by the inequality within the industrial sector, while the agricultural sector only contributed 1.2% to overall inequality in 2017.

This is a very important finding and it suggests that the uneven distribution of output of the service sector is the crux of the problem of inequality in the world. Industrial sector also contributed a lot to overall inequality, however, the magnitude is much less and it is only one third of that of the service sector. Combining together, the total contribution of the two sectors is more than 98%, while the contribution of the agricultural

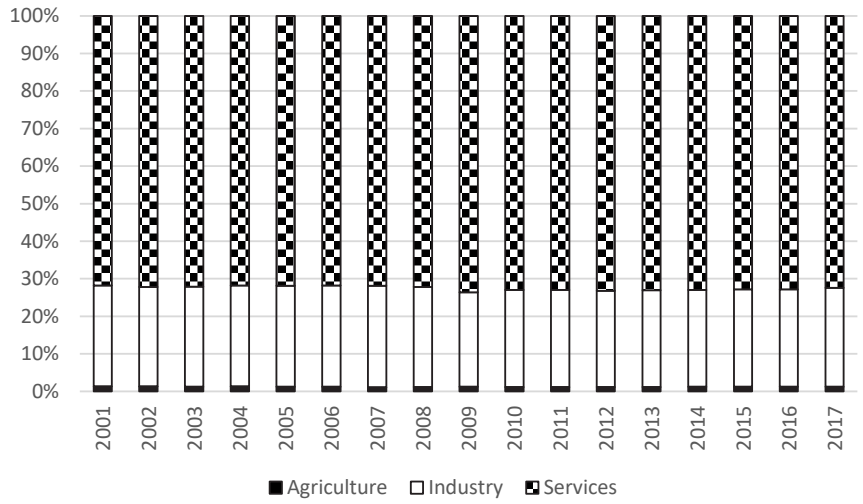

FIGURE 2 | Decomposition of inequality for the world, 2001 to 2017. Source: Authors' calculation.

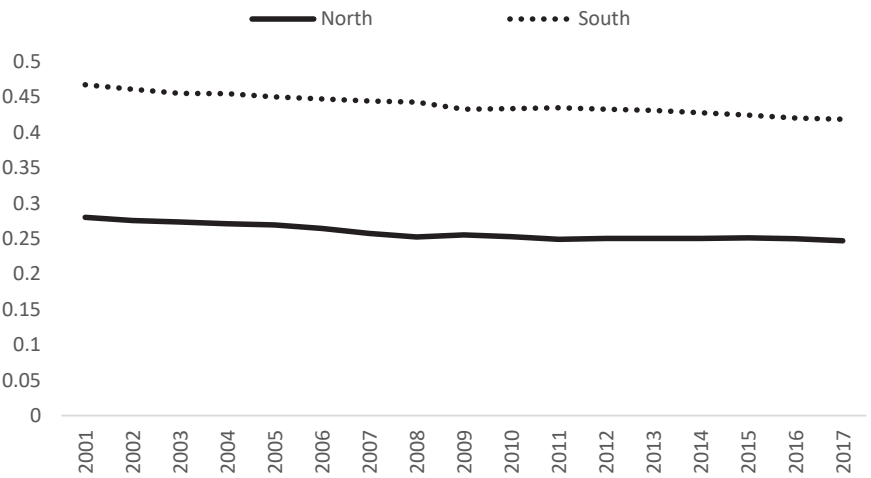

FIGURE 3 | Gini coefficients for the North and South, 2001 to 2017. Source: Authors' calculation.

sector is negligible. This finding pinpoints the importance of the industrial and service sectors. The governments in the developing countries should divert more resources to these two sectors and encourage further investments in them so as to promote long-term economic growth.

North-South Divide

The next stage of this study is to examine the North-South Divide. The trends of the Gini coefficient of the North and South are shown in **Figure 3**. It can be observed that the inequality within the South was higher than that of the North. However, the inequalities in both regions declined in the study period. The Gini coefficient of the South fell from 0.47 in 2001 to 0.42 in 2017, while the Gini coefficient of the North dropped from 0.28 to 0.25. It shows that the disparity within both regions had narrowed across time. However, the large disparity within the developing countries is a warning sign for pursuing the SDGs.

Apart from the evolutionary trend of inequality, the next burning issue is whether the classification of North and South has any impacts on the contribution of the three sectors to overall inequality. **Figure 4** shows the decomposition results for each group in detail. It can be observed that in 2017, the largest contributor for the North was the service sector and its contribution was more than 80%, while industrial sector was about 20% and contribution of the agricultural sector is negligible. Moreover, the contribution of the service sector had increased from 77.6% in 2001 to 80.2% in 2017, and the contribution of the other two sectors dropped slightly in that period, thereby suggesting that the service sector had gained in relative importance in terms of overall inequality. This is a rather distributing finding as it suggests that the situation may deteriorate further for the developed countries which are already subject to the high disparity in output of the service sector.

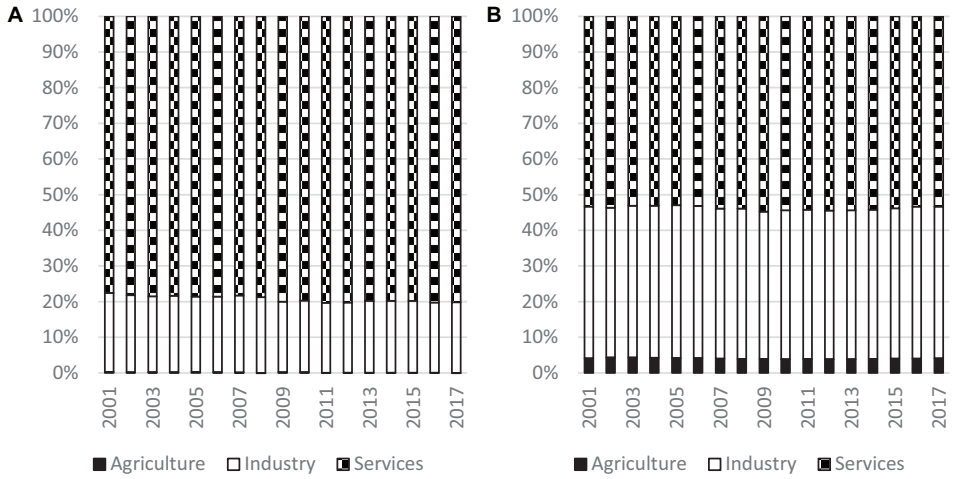

FIGURE 4 | Decomposition of inequality for the North and South, 2001 to 2017. Source: Authors' calculation. **(A)** North and **(B)** South.

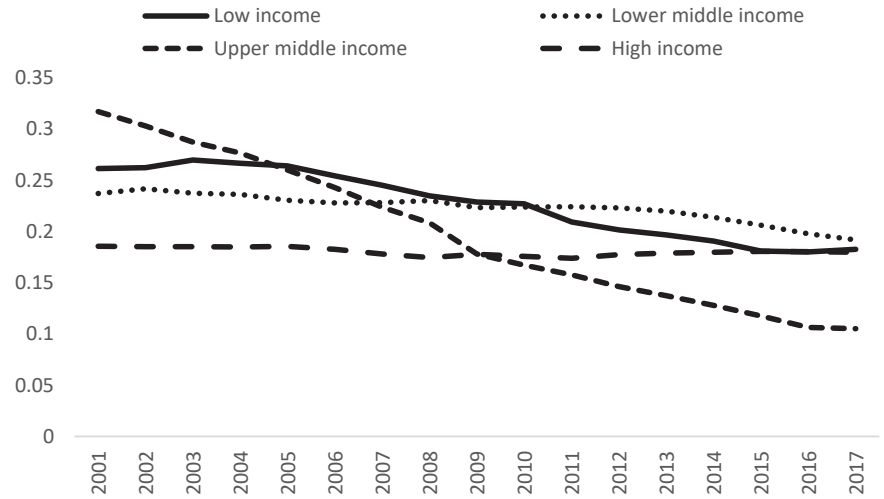

FIGURE 5 | Gini coefficients for different income groups, 2001 to 2017. Source: Authors' calculation.

Turning to the South, the largest contributor in 2017 was also the service sector, and its contribution to overall inequality was 53.4%. The contribution of the industrial sector was 42.5% and agricultural sector was 4.1% in that year. Although service sector contributed the most, however, the industrial sector also played a major role in inequality. The two sectors contributed more than 95%. It is notable that the contribution of the three sectors in the South remained fairly constant in the study period.

In summary, by comparing **Figures 4A,B**, it can be concluded that the service sector was the largest contributor to overall inequality for both groups, followed by the industrial sector, while the contribution of the agricultural sector was negligible. The huge disparity in the service sector was more marked in the North than in the South. Moreover, the findings show that the situation had worsened across time. It is also worth mentioning that the industrial sector played a major role in the South and contributed more than 40% to overall inequality, thereby highlighting the fact that the governments of developing countries should also focus on industrial development rather than focusing only on the service sector.

Comparison Across Income Groups

The data were separated into four datasets based on the income level of a country according to the scheme proposed by the World Bank. The countries were grouped into four income groups, namely, the low-income, the lower-middle, the upper-middle, and the high income groups. The evolution of the trend is shown in **Figure 5**. Back in 2001, the upper-middle-income group had the highest level of inequality amongst the four, and its Gini coefficient was 0.32, followed by the low-income group with a Gini coefficient of 0.26. The Gini coefficient in the lower-middle-income group was 0.24, and the high-income group had the lowest level of inequality (0.19) in 2017.

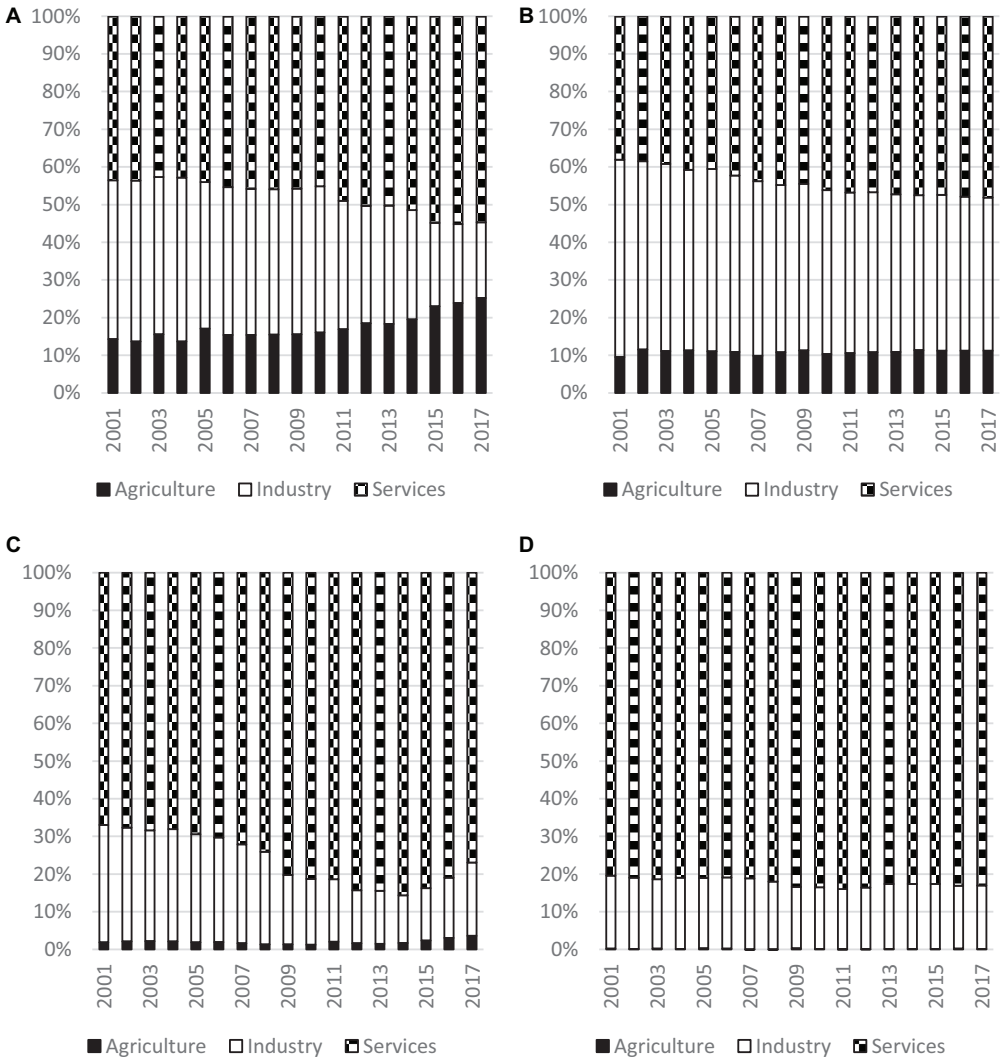

FIGURE 6 | Decomposition of Inequality for Different Income Groups, 2001 to 2017. Source: Authors' calculation. **(A)** Low, **(B)** Lower-Middle, **(C)** Upper-Middle, and **(D)** High.

Surprisingly, the inequalities within all the income groups had declined. The Gini coefficient for the low-income countries fell from 0.26 in 2001 to 0.18 in 2017 with a reduction of more than 30%. This is an encouraging finding and it shows that the disparity amongst the poor countries was reduced considerably. Turning to the lower-middle-income countries, the Gini coefficient dropped from 0.24 to 0.19 with a fall of 19%. The decline was moderate compared with that of the low-income group.

Figure 5 shows that there was a huge drop in the inequality within the upper-middle-income group. The Gini coefficient dropped from 0.32 to 0.11 in the study period, with an overall reduction of 67%. This is an extraordinary achievement and the countries within this group had a significant decline in overall inequality across time. The upper-middle-income countries had the lowest level of inequality amongst the four income groups due to this improvement in 2017. This finding shows that international inequality can be mitigated, thereby suggesting that the SDGs are within reach and can be achieved through international cooperation and careful planning of development policy.

Turning to the high-income countries, although the Gini coefficient had dropped from 0.19 to 0.18, the decline is only 3.2%. In fact, the reduction in inequality within the high-income countries was the smallest amongst the four income groups. It shows that the progress in inequality alleviation was much slower than the other income groups.

The decomposition results of the four income groups are shown in **Figure 6**. It can be observed that the change in contribution is very different for all the income groups. For the low-income subgroup, the percentage contribution of the agricultural sector increased from 14.3 to 25.2% resulting in an increase of 10.9%, the contribution of the service sector increased from 43.5 to 54.7% for an increase of 11.2%, while the industrial

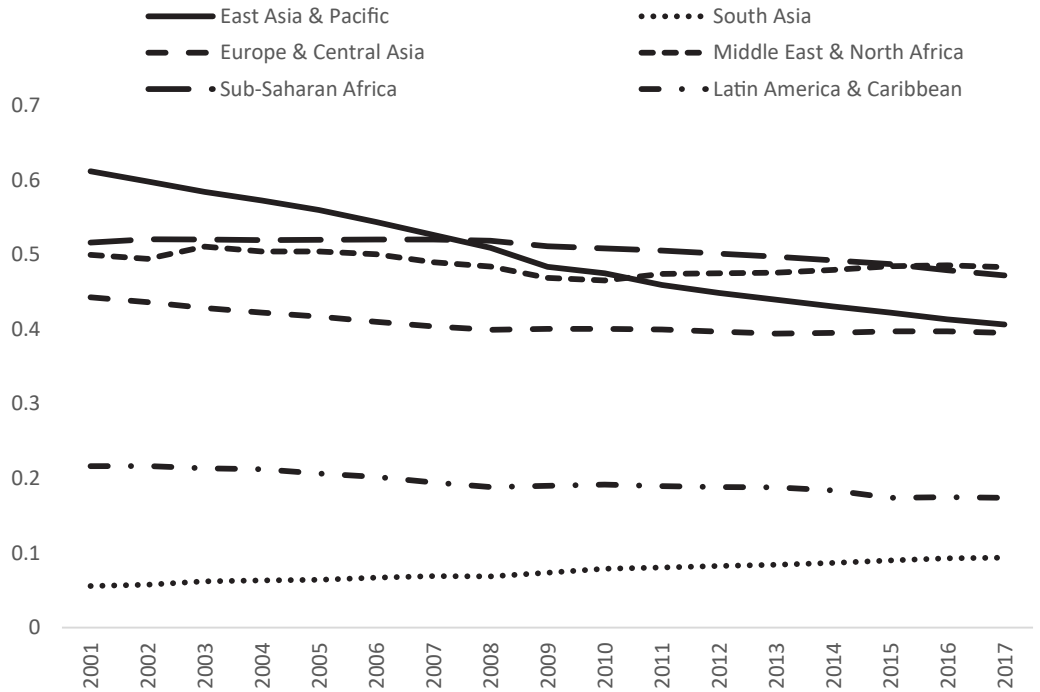

FIGURE 7 | Gini coefficients for different regions, 2001 to 2017. Source: Authors' calculation.

sector suffered from a huge decline. The contribution of the industrial sector fell from 42.2 to 20.1% resulting in a decline of 22.1%. This is unanticipated as it shows that the role of the industrial sector had been reduced in the study period. Almost half of the decline in contribution of the industrial sector was replaced by the increase of the contribution of the service sector, however, it is surprising to note that the other half was due to the rise in contribution of the agricultural sector.

Figures 6B,C shows the decomposition results of the lower-middle-income and the upper-middle-income groups, respectively. They exhibited similar patterns to the low-income group. The contribution of the industrial sector had declined in the study period, while the contribution of the agricultural and service sectors had increased. It can be observed that the increase in contribution of the service sector was higher than the agricultural sector for all the three income groups.

Turning to the high-income group, **Figure 6D** shows that the contribution of the service sector had decreased within the study period. However, the contribution of both agricultural and industrial sectors fell within that period. In fact, only the agricultural sector in the high-income group showed a drop in contribution, while the agricultural sector in all the other three income groups showed an increase. However, the drop in contribution of the agricultural sector is negligible for the high-income group as the contribution was 0.23% in 2001 and 0.13% in 2017, resulting in only a decline of 0.1%.

It is of interest to compare the evolution patterns of all the income groups. There are some interesting observations: First, the largest contributor to inequality was identified to be the service sector for all the income groups. Second, for the high-income, upper-middle-income, and lower-middle-income groups, the second highest contributor was the industrial sector in 2017, while the agricultural sector contributed the smallest amount. However, it is a little different for the low-income group as the contribution of the agricultural sector was higher than that of the industrial sector. Third, except for the low-income group, it can be observed that the higher the income, the higher the percentage contribution of the service sector. The contribution of the service sector was 83.0% for the high-income group, 76.9% for the upper-middle-income group, 48.2% for the lower-middle-income group and 54.7% for the low-income group. Fourth, the contribution of the service sector had increased, while the contribution of the industrial sector had declined for all the income groups. Finally, the contribution of the agricultural sector had declined for the high-income group, while the contribution of this sector had increased for all other income groups, thereby signifying the insignificance of the agricultural sector for the high-income group.

Comparison Across Regions

The next stage of this study is to examine the impacts of regional groupings on the contribution of inequality. The results are provided in **Figure 7**. It is notable that the inequalities in almost all the regions had declined in the study period, however, the inequality in South Asia had risen. In 2017, Middle East and North Africa had the highest level of inequality (0.48), followed by Sub-Saharan Africa (0.47). The inequality in East Asia and Pacific (0.41) was similar to that in Europe and Central Asia (0.40). Latin America and Caribbean had the second lowest inequality (0.17), while South Asia had the lowest level of

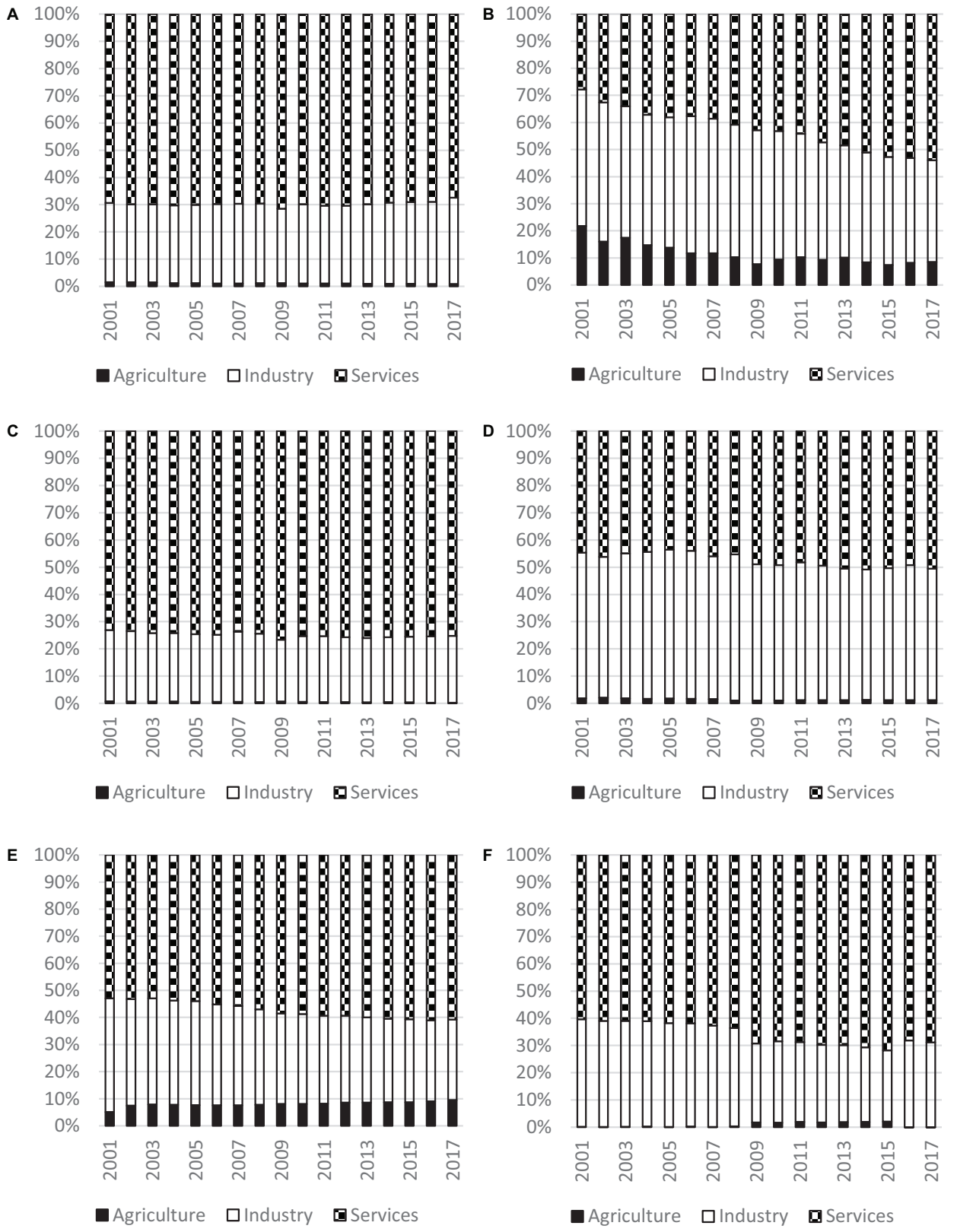

FIGURE 8 | Decomposition of inequality for different regions, 2001 to 2017. Source: Authors' calculation. **(A)** East Asia and Pacific, **(B)** South Asia, **(C)** Europe and Central Asia, **(D)** Middle East and North Africa, **(E)** Sub-Saharan Africa, and **(F)** Latin America and Caribbean.

inequality within its region (0.09). It shows that the characteristics are very different for the regions, thereby calling for further investigation for each region individually.

Decomposition by income sources were conducted for each region individually, and the results are shown in **Figure 8**. It can be observed that the contribution of the service sector had increased for all the regions except that of the East Asia and Pacific. It is notable that East Asia and Pacific is quite unusual as the contribution of the service sector had declined from 2001 to 2017, while that of the industrial sector had increased. In fact, East Asia and Pacific is also very special in terms of industrial development. The contribution of the industrial sector had increased for East Asia and Pacific, but decreased for all the other regions. Turning to the agricultural sector, the contribution of that sector had increased for Sub-Saharan Africa, but decreased for all other regions.

There are several other salient findings. First, the largest contributor to inequality was the service sector for all the regions. The contribution was 75.2% for Europe and Central Asia which had the highest level of contribution in 2017, while Middle East and North Africa had the lowest level of contribution and the value was 50.6%. It suggests that service sector had played a major role in global income inequality and contributed more than 50% to overall inequality for all the regions. Second, the industrial sector is identified to be the second largest contributor to overall inequality in all the regions, thereby signifying the importance of the industrial sector. Third, the agricultural sector contributed the least amount to overall inequality. The contribution of the agricultural sector in most regions are below 1.5%; however, it was 9.5% in Sub-Saharan Africa, and 8.4% in South Asia. It implies that a lot of people in these regions still rely on the agricultural sector for a living, and the development in the industrial and service sectors in these two regions lagged behind those of the other regions.

In summary, although the service is deemed to be the most important player in regional inequality, East Asia and Pacific is getting more and more susceptible to the disparity in industrial development, while Sub-Saharan Africa is prone to the inequality within the agricultural sector. These findings suggest that each of the region has very different pattern of evolution of inequality, therefore, it is necessary to take geographical location into consideration in formulating development policies.

CONCLUSION

It is worth noting that the data used in this study does not cover the period after the spread of COVID-19. Given that global inequality can be aggravated further as many developing countries may suffer more from the pandemic due to a lack of resources, one can expect that global inequality may be much worse than the results derived from this study in the short run. However, in the long run, it can be expected that inequality should be driven by the economic structure when things resume back to normal after the pandemic.

The scale and ambition of SDGs "requires a revitalized Global Partnership to ensure its implementation. This Partnership will work in a spirit of global solidarity. It will facilitate an intensive global engagement in support of implementation of all the Goals and targets, bringing together Governments, the private sector, civil society, the United Nations system and other actors and mobilizing all available resources" (Hong, 2016). In response to this general principle, this paper explores several crucial issues so as to enrich the knowledge base of inequality by employing decomposition analysis and studying the underlying transitional dynamics behind the trend.

This study aims to study the evolution of inequality by focusing on the impacts of the economic structure. The technique of decomposition by income sources is employed to evaluate the contribution of the three major sectors, namely the agricultural, industrial, and service sectors to overall inequality. The data were compiled from the World Bank. The data cover almost all the countries in the world from 2001 to 2017 for a total of 18 years. There are four stages of analysis in this study. The first stage of study is to provide an overall view of the evolutionary trend of global inequality, the second stage focuses on the North-South divide, the third stage determines the impacts of income groups, and the fourth stage investigates the impacts for each region. This approach enables us to study the contribution of the three sectors in great detail, so that pertinent policy implications can be derived from the results.

There are several salient findings: First, global inequality had declined in the study period. Second, the service sector is identified as the largest contributor to global inequality, followed by the industrial sector, while the contribution of the agricultural sector is negligible. For the North-South divide, disparity in the service sector was more marked in the North than in the South. The industrial sector played a major role in the South and contributed more than 40% to overall inequality, thereby suggesting that the governments of developing countries should also focus on industrial development.

For the comparison amongst the income groups, our findings show that the higher the income, the higher the percentage contribution of the service sector (except for the low-income group). The contribution of the service sector had increased, while the contribution of the industrial sector had declined for all the income groups. Interestingly, the contribution of the agricultural sector had declined for the high-income group, while the contribution of this sector had increased for all other income groups.

Finally, for the comparison across regions, although the contribution of the agricultural sector in most regions are below 1.5%; however, the contribution of the agricultural sector in both Sub-Saharan Africa and South Asia is more than 8%. It implies that a lot of people in these regions still rely on the agricultural sector for a living, and the development in the industrial and service sectors in these two regions lagged behind those of the other regions. Our analysis show that the evolution pattern is very different for each region, therefore, it is necessary to take the effects of income and geographical location into consideration in formulating development policies. This study not only can reveal the evolution of inequality and the contribution of each sector across time, but also can provide relevant information for allocating scarce resources in promoting economic development.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

NM: data collection, data preparation, and writing. VL: literature review, data cleaning, and writing. TC: conceptualization, data curation, methodology, and software. DZ: discussion, writing, and editing. All authors contributed to the article and approved the submitted version.

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Research on the Influence of Dynamic Work Environment on Employees' Innovative Performance in the Post-epidemic Era – The Role of Job Crafting and Voice Behavior

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In today's interconnected world, environmental uncertainty is higher than ever. Under the new economic normal, innovation-driven has become the key to the transformation and upgrading of various enterprises. Employees' behavior affects the company's innovative performance, but it is also deeply affected by the dynamic work environment. The sudden epidemic has greatly increased the environmental dynamics and uncertainties faced by individuals, and also caused many changes in individual behavior. However, the research on the mediating mechanism and boundary conditions of how the dynamic work environment affects employee behavior and results is relatively few. Based on uncertainty reduction theory and innovative performance theory, and following the research paradigm of "environment-behavior-performance," a moderated mediation model with job crafting as the mediating variable and voice behavior as the moderating variable is constructed. Through the statistical analysis of 210 valid questionnaires for employees in different types of enterprises, the mechanism of how the dynamic work environment affects innovative performance by promoting employees to carry out job crafting is discussed. According to the test results, the dynamic work environment has a significant positive impact on individual innovative performance, and job crafting plays a mediating role in the relationship between the two. In addition, voice behavior positively moderate the relationship between dynamic work environment and job crafting, and the indirect relationship between dynamic work environment and innovative performance through job crafting.

Keywords: dynamic work environment, innovative performance, job crafting, voice behavior, mediation effect

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INTRODUCTION

With the transformation of enterprises from an industrial economy to a knowledge economy, competition among enterprises has become increasingly fierce. Due to the development of emerging technologies such as "Internet +," cloud computing, and block-chain, various new industries, new formats, and new models are constantly emerging, bringing huge opportunities and challenges to enterprises. In today's interconnected world, the environment is more uncertain and

dynamic than ever before. Facing the uncertainty and dynamics of the environment, enterprises must solve the problem of how to promote the long-term development of the organization through innovation, so as to improve organizational performance, and maintain a unique competitive advantage in the era of technological iteration and change. Therefore, innovation is not only a trend in increasingly competitive dynamic environment, but also a necessary way for enterprises to gain competitive advantage. The innovative performance of an enterprise depends on the innovation behavior of employees. Employee innovation is the foundation of enterprise innovation. Under the catalysis of time, a certain number of individual-level innovation will bring qualitative changes to the organization and give the organization a new lease of life. Therefore, the continuous accumulation of employee innovation has contributed to the production of organizational innovation, which is one of the decisive factors of organizational innovative performance (Amabile, 1993; Welbourne et al., 1998). In this situation, research on employees' innovative performance is particularly important. Seeking to stimulate employee innovation and improve the effectiveness of their innovation activities has also aroused widespread concern from academia and enterprises.

Global competition continues to intensify, technology continues to update, and the pressure to survive has become more obvious. These changes have made every organization and individual in a dynamic environment with full of uncertainties (Chen et al., 2018). How to face the dynamic environment with full of challenges and opportunities has become one of the biggest challenges for organizations and individuals. In particular, the sudden outbreak of COVID-19 epidemic has involved many organizations in a huge crisis, causing both organizations and individuals to face a high degree of uncertainty and complexity. The epidemic is a heavy test for everyone, every company, and the entire country and the world. After this epidemic crisis, it must be an accelerated process of elimination and upgrade for both organizations and individuals. Those organizations and individuals with rapid upgrade capabilities will be able to adapt and make full use of the challenges and opportunities brought by the dynamic environment, thereby improving the organization and individual performance. As an effective management measure to deal with complex and dynamic environments, work design has become an important focus of organizational management (Brenninkmeijer and Hekkert-Koning, 2015). Just as under this epidemic, many domestic organizations have chosen the "new work" model of working at home. Different from the traditional office mode, working at home is a working mode that requires online, independent, and collaborative work, which requires work redesign. In traditional management, work design is a top-down process, that is, managers are responsible for restructuring the work of employees. However, one of the criticisms of this approach is that continuous changes and increasing complexity in the work environment are not taken into consideration (Grant and Parker, 2009). Therefore, Grant and Parker (2009) suggested that managers in organizations no longer need to design fixed and static jobs, but need to provide more flexible jobs. In these jobs, employees can actively change and develop tasks on their own to respond to job needs and opportunities.

Effectively stimulating the initiative and creativity of employees in a dynamic and complex environment is the key to a company's control of uncertainty. The dynamic changes of the environment and the enhancement of employees' individual awareness mean that organizations need to shift their perspective to the proactive behavior of employees. In the proposition of work design, employees can also actively participate in it, and the concept of job crafting came into being. During the COVID-19 epidemic, medical staff rushed into battle, willing to contribute, and reshaped the mission and value of their job. During the resumption of work, employees worked remotely and reinterpreted their working relationships. The post-90s and even post-00s have embodied the spirit of responsibility of the new generation of employees. Studies have shown that when employees are in an environment with greater work pressure and higher autonomy, they will proactively implement their job crafting (Tims et al., 2013). The job crafting behavior of individuals to work will further affect employees' performance (Tims et al., 2015; Rudolph et al., 2017). In addition, recent research also pointed out that in increasingly complex and changeable dynamic work environment, employees' voice behaviors will also play a direct and indirect moderating role.

On the one hand, dynamic work environment will expose employees to a large number of potential development opportunities. On the other hand, dynamic work environment will also bring unforeseen accidents or disturbances to employees' work and career development. The work pressure faced by employees has increased significantly, and small work errors may cause greater losses (Waldman et al., 2001). In this uncertain situation where challenges and opportunities for change coexist, employees must find ways to adapt to environmental changes, develop and utilize environmental opportunities, and avoid environmental risks. Employees may take the initiative and spontaneously adjust their own status, make more work input, and design and adjust their work content and boundaries. According to resource protection theory and social exchange theory, in the process of job crafting, employees will actively make voice behavior for the purpose of protecting their own resources or creating value for the organization. If employees' voice behavior is recognized by their bosses and colleagues, employees will be more proactive in finding a match between the individual and the work, and will be more proactive in making voice behavior to the work. Existing research has shown that employees' voice behavior has a positive effect on the improvement of innovation performance (Ng and Feldman, 2012). With the reduction of social resources, active work input, negative mentality and psychological pressure, employees continue to update their knowledge and improve their work skills at work. All of these provide a strong basic guarantee for employees' innovation activities and are conducive to the improvement of employees' innovation performance.

The contribution of this research is mainly reflected in the following aspects: First, it enriches the research between dynamic work environment and its result variables. This research confirms that the cognition of the dynamic work environment

can promote the innovation performance of employees, thus enriching and expanding the research between the dynamic work environment and its results. Second, by introducing the mediating variable of job crafting, this research can discover the key role played by the environment characteristic variables of employees, and also supports the important role of job crafting. This provides a new perspective for explaining the relationship between the dynamic work environment and innovation performance, opens the "black box" of positive effects in the dynamic work environment, and provides a good realistic explanation for the performance dilemma of employees in the post-epidemic era. Finally, by constructing a moderated mediation model, it more comprehensively reflects the complex process of the dynamic work environment affecting innovation performance of employee. On the basis of self-loss theory (Prem et al., 2016) and social information processing theory (Frazier and Bowler, 2015), the introduction of voice behavior as a moderating variable confirms the important role of employees' participation in organizational management.

The following section presents the relevant literature review and forms hypotheses for testing. The methodology of testing the hypotheses is outlined, followed by the analysis of the results. Discussion, implications, conclusion as well as the limitations and future research are provided in the final section.

LITERATURE REVIEW AND HYPOTHESES

Dynamic Work Environment and Innovative Performance

Dynamic is a key feature of the environment, which refers to a certain degree of rapid, unpredictable and turbulent changes (Eisenhardt and Martin, 2000). The dynamic environment mainly emphasizes the speed, complexity and way of environmental change (Rodriguez-Pea, 2021), and the uncertainty and unpredictability that it brings (Rosenbusch et al., 2013). Scholars generally divide environmental dynamics into technological development dynamics and market demand dynamics, which mainly include unpredictability of customers, market trend change rates, peer competitors, business growth opportunities, R&D process (Rodriguez-Pea, 2021). In addition, environmental dynamics are related to uncertainty, which weakens the employer's ability to predict events and their impact on the organization (Lumpkin and Dess, 2001).When the environment is full of dynamics, meeting the latest requirements and changes in the environment may greatly affect the survival and development of the organization. Therefore, how to deal with the uncertainty brought about by the dynamic environment has become an important factor that must be considered in modern organization management (Hmieleski and Ensley, 2007; Ember, 2013; Diakanastasi et al., 2018; Smithson et al., 2019).

The impact of the dynamic work environment on the organization and employees should not be underestimated. The strength of uncertainty affects the behavior of organizational managers and employees in facing environmental changes with the complexity, ambiguity and turbulence (Fiedler, 2015). In a dynamic work environment, both organizations and employees must find ways to deal with the opportunities and challenges that the environment brings. For example, the outbreak of the epidemic has caused many organizations and employees to change their traditional working methods and switch to telecommuting to start and resume work. This dynamic change in the work environment profoundly affects the behavior of individuals in the organization. Studies have pointed out that the adjustment and change of work methods during the epidemic will not only affect the efficiency of the organization and the cost of personnel communication (Glac and Zdebska, 2020), but also have a corresponding impact on the psychology and behavior of employees in the organization (Julio et al., 2020), easy to intensify work-family conflict (Zhou et al., 2020), and even affect employees' perception of career prospects (Mao et al., 2020). Baron and Tang (2011) pointed out that the dynamics of the environment may be a catalyst for the innovative behavior of organizations and individuals. When faced with uncertainty, people tend to show certain behaviors to reduce uncertainty (Deng et al., 2019). From the perspective of individual attention, employees in a dynamic work environment will pay more attention to changes in the environment. When employees pay more attention to the environment rather than themselves, they will take a more accurate self-assessment in consideration of the overall situation (Aron et al., 1992) and adopt corresponding behavioral strategies to respond positively to uncertain environments, for example, employees do the job crafting to improve work performance.

Employees' innovative performance is a good idea or result generated and realized by an individual, which can benefit organizational performance (Fan et al., 2016). Employees' innovative performance is achieved through their innovative activities. Innovative performance includes not only the results of innovation, but also the generation and promotion of innovative ideas and innovation support to the organization (Hagedoorn and Cloodt, 2003). As the output of corporate development strategy, employee innovation performance is an infinite source of sustainable development for an organization (Chen et al., 2016). At the same time, with the profound and complex changes in the environment, in order to seek greater development, organizations have higher and higher requirements and expectations for the innovation ability and innovation performance of the workforce. Previous discussions on the relationship between environmental uncertainty and performance have mostly focused on research at the enterprise or management team level (Li and Zhao, 2016; Deng et al., 2019). For example, in the face of an uncertain environment, organizations can implement mergers and acquisitions, design, and flexible human resource management strategies (Wan and Yiu, 2009), improvisation and reallocation of resources (Tseng et al., 2015), perceive and grasp potential opportunities (Li and Atuahene-Gima, 2001) and other ways to gain a competitive advantage and improve organizational performance. However, dynamics is not only a challenge for organizations and leaders, but also for employees. Küller et al. (2006) believe that the work environment has an impact on human psychology. Especially

under this epidemic, many employees have found that their work environment is full of changes, challenges and opportunities. Thomas and Obal (2018) believes that in the case of rapid changes in the external environment, employees' role pressure will increase, and employees need a wealth of knowledge to balance the negative effects of uncertainty. First, in a dynamic work environment, employees will be more likely to adopt positive behavior strategies to reduce uncertainty, so as to carry out their work more effectively and improve their innovative performance. Second, there are opportunities for change in a dynamic work environment. When individuals can effectively identify opportunities in a dynamic work environment and can more actively face changes in the environment, their work attitudes will become more positive (De Hoogh et al., 2004), and their work will be more productive. Research has found that under the role of work adjustment theory, employees and the work environment often reach a state of conformity. Employees will adjust themselves according to the degree of conformity and show different behavior styles (Bradley et al., 2002). Therefore, when faced with a dynamic work environment, employees will be more likely to pay attention to the opportunities and challenges in the environment, re-understand and evaluate their own environment and current situation, and actively take actions to improve and their job crafting. Their ultimate goal is to be able to carry out and complete work more effectively in a dynamic work environment, and strive to improve innovative performance. As such, the following hypothesis is offered.

H1: Dynamic work environment has a positive impact on employees' innovative performance.

The Mediating Effect of Job Crafting

According to the purpose of this research, this study constructs the theoretical framework of "dynamic work environment-job crafting-innovative performance". Job crafting is a kind of "contextualized" activity, embedded in the environment, and its behavior itself and its results are affected by the characteristics of the environment (Zhang and Parker, 2019). Different work situations enable different forms of job crafting to be realized or have different degrees of impact (Wrzesniewski and Dutton, 2001). Job crafting is essentially an employee-led job redesign. They change environment to match their work with their abilities and preferences (Tims and Bakker, 2010). Since job crafting is an initiative of employees, it is described as a personalized, bottom-up, and proactive design method compared with the top-down and "one size fits all" work design methods initiated by the organization (Grant and Parker, 2009; Parker, 2014). The motivations for employees' job crafting are not only including personal subjective factor but also the influence of job characteristics (Wrzesniewski and Dutton, 2001; Tims et al., 2015). For example, individual needs provide internal motivation for job crafting (Bindl et al., 2019). Employees with high work autonomy have more autonomy in role expansion, idea implementation, and problem solving, which makes it easier to make job crafting (Bizzi, 2017). When environmental changes bring beneficial and challenging work requirements to the personal development of employees, employees will actively implement job crafting (Li et al., 2014).

According to the uncertainty reduction theory, when faced with dynamic changes in the work environment, employees will take a series of actions to reduce the uncertainty they face, so they are more likely to respond to challenges and changes by actively changing work tasks. According to the theory of resource preservation, individuals with more resources will obtain resources in the process of interacting with the surrounding environment, and make full use of various opportunities to create resource surpluses to resist other losses. In other words, in the process of job crafting, employees hope to obtain more resources to achieve resource appreciation, that is, performance improvement.

As a series of behaviors independently carried out by employees, job crafting can improve work performance by increasing work input, adaptability and enthusiasm, and can bring out positive results of person-work matching, and achieving a win-win of work meaning and work performance (Leana et al., 2009; Tims et al., 2015). Studies have shown that job crafting will bring many positive effects, such as helping employees find meaning in their jobs (Wrzesniewski et al., 2013), promoting employees' work engagement (Vogt et al., 2015), and improving person-work matching (Tims et al., 2016), affecting employees' innovation performance (Tuan, 2018). According to the theory of human-environment matching and related research on innovative behaviors, job crafting changes the work boundary and content according to the independent wishes of employees, increases the level of work resources-requirement balance, and improves their work commitment and satisfaction. These can improve employees' efficiency. In the process of job crafting, employees will try new methods to complete work tasks, flexibly use various work resources, and enhance their ability to respond to emergencies at work, thereby enhancing their work performance in a dynamic work environment. The increase in work resources, work engagement and satisfaction can stimulate employees' intrinsic motivation and encourage them to perform innovative behaviors after completing their jobs efficiently (Demerouti et al., 2015). Individuals increase the matching degree of work with their own abilities, interests and preferences through job crafting, which not only promotes them to give full play to their subjective initiative, but also benefits them to better complete work tasks and improve work performance (Tims and Bakker, 2010; Tims et al., 2015). From the perspective of the three aspects of employee innovation behavior, job crafting has changed the content and boundaries of work. Employees have more opportunities to discover new problems and contradictions in new work situations, which can stimulate the generation of new ideas for employees. Job crafting also includes changing the interpersonal relationships at work and adding more interpersonal resources and interactions. These interpersonal resources can provide support and assistance for employees when new ideas are promoted, and promote employees' innovative activities (Afsar et al., 2019). At the same time, through the employees' job crafting, team work efficiency may be improved. In the process of applying employees' new ideas, team collaboration capabilities are enhanced, which is

conducive to the implementation of innovative applications. Therefore, the following hypothesis is offered.

H2: Job crafting plays a mediating role in the influence of dynamic work environment on employees' innovative performance.

The Moderating Role of Voice Behavior

Research shows that with the deepening of social cognition and psychological capital theoretical research, as well as the profound changes in the employment relationship between organizations and employees, the voice behavior generated by the proactive personality will have an impact on job crafting behavior and innovative performance. The research on voice behavior was first proposed by Hirschman in 1970. He believed that voice behavior was an expression of whether employees were satisfied with their work. The higher the satisfaction, the more inclined employees are to implement voice behavior (Hirschman, 1970). Van et al. (2003) defined the act of voice behavior as proposing ideas and opinions related to one's own work based on a certain cooperative motivation. From the perspective of the specific content of voice behavior, Liang and Farh (2008) divided the voice behavior into promotive and prohibitive voice behavior, and Janssen and Gao (2015) defined the voice behavior as traditional and novel voice behavior. In terms of composition, voice behavior not only covers the promotive behavior that promotes something to happen, but also covers the prohibitive behavior that promotes the disappearance of something.

In a dynamic work environment, voice behavior is a way of interaction between employees and the organization. On the one hand, voice behavior indicates that employees are encountering cognitive conflicts. On the other hand, it means that employees are open and accepting when facing cognitive conflicts (Ou et al., 2018). First of all, previous studies have shown that employees' voice behavior increase their work cognitive resources, and the balance between their existing work resources and requirements is broken. Therefore, it is possible to produce job crafting behavior, further improve their work status, and make their work resources more consistent with each other in a new balance. Second, some studies have pointed out that employees' voice behavior can improve the interpersonal relationship among employees and enable employees to maintain a good working mood (Tjosvold and Su, 2007).Moreover, positive interpersonal relationships and work emotions are a social interpersonal resource at work (Tims et al., 2016). This increase in resources will break the balance of previous work requirements and resources, and drive them to implement job crafting. According to the theory of active behavior motivation, positive emotional attitudes can also drive employees to take active behaviors. Therefore, employees' voice behavior will have an impact on interpersonal relationships, affect employees' emotional attitudes at work, and provide positive emotional protection for employees' job crafting behavior that spontaneously expands their work boundaries. Therefore, the following hypotheses are offered.

H3a: Promotive voice behavior will positively moderate the impact of the dynamic work environment on job crafting. That is, when employees adopt promotive voice behavior, they are more likely to adopt job crafting in a dynamic work environment.

H3b: Prohibitive voice behavior will positively moderate the positive impact of the dynamic work environment on job crafting. That is, when employees adopt prohibitive voice behavior, they are more likely to adopt job crafting in a dynamic work environment.

Hypothesis H2, H3a, and H3b together construct a mediation model with moderating. As employees' voice behavior can moderate the relationship between dynamic work environment and job crafting, this research further predicts that the impact of dynamic work environment on innovative performance through job crafting will also be moderated by employees' voice behavior. In the research on individual performance of employees, many studies believe that employees' voice behavior can significantly improve process fairness and result fairness (Cohencharash and Spector, 2001), thereby helping employees improve their sense of job control and self-efficacy, and have a positive effect on employees' innovative performance (Whiting et al., 2008). Studies have shown that employees who regularly implement voice behavior will pay more attention to the status of the organization and think more positively, so they will also get a high level of performance. A study by Ng and Feldman (2012) found that employee's voice behavior has a strong predictive effect on innovation ability and the implementation of innovative thinking. This paper believes that whether it is promotive or prohibitive voice behavior, it can positively moderate the relationship between job crafting in the dynamic work environment and innovative performance. Therefore, the following hypotheses are offered.

H4a: Employees' promotive voice behavior will moderate the mediating role of job crafting in the relationship between dynamic work environment and innovative performance. That is, the higher the level of promotive voice, the stronger the mediating role of job crafting.

H4b: Employees' prohibitive voice behavior will moderate the mediating role of job crafting in the relationship between dynamic work environment and innovative performance. That is, the higher the level of prohibitive voice, the stronger the mediating role of job crafting.

In summary, the construction model of this research is shown in **Figure 1**.

RESEARCH DESIGN

Research Objects and Questionnaires

The post-epidemic era is a period of normalization and uncertainty. The data collection for this study is in March-April 2021.The research sample mainly selects employees

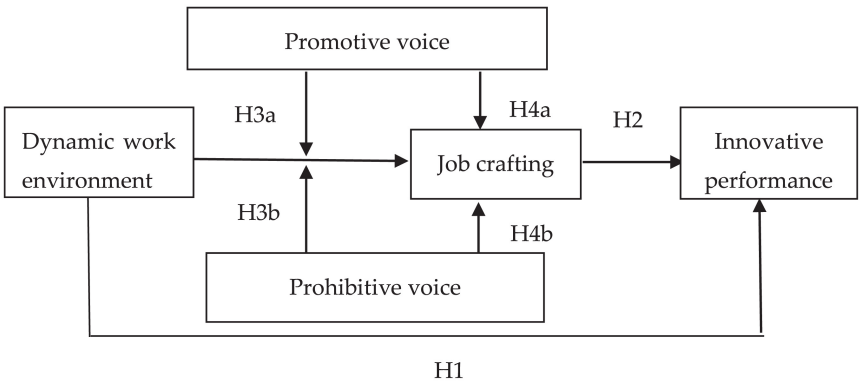

FIGURE 1 | Theoretical model.

TABLE 1 | Demographics of the survey respondents.

Variable		*N*	Percentage	Variable		*N*	Percentage
Gender	Male	108	51.43%	Industry	Electronic information	70	33.33%
	Female	102	48.57%	Industry	New material	35	16.67%
Age	≤ 25	31	14.76%	Industry	Biomedicine	48	22.86%
	[26, 35]	112	53.34%	Industry	New energy	37	17.62%
	≥ 36	67	31.90%	Industry	Others	20	9.52%
Education	High school	50	23.81%	Job	Planning and operation	34	16.19%
	Bachelor degree	125	59.52%	Job	Management	48	22.86%
	Graduate degree	35	16.67%	Job	R&D	51	24.29%
Years	≤ 1	34	16.19%	Job	Finance	32	15.24%
	[2, 5]	90	42.86%	Job	Marketing	45	21.42%
	≥ 6	86	40.95%				

from some companies in the Suzhou National High-tech Industrial Development Zone in China, and has experience of working at home. The formal survey is conducted through a self-managed online questionnaire system and is conducted by random sampling. The formal survey was completed within two months. During the investigation, the respondents were required to answer questions objectively and fairly based on the principle of seeking truth from facts. A total of 240 questionnaires were distributed in this study. After excluding invalid questionnaires, 210 valid questionnaires were obtained, with an effective rate of 87.5%. In terms of sample distribution, the distribution of male and female ratios is relatively balanced. The age distribution is mainly 26-35 years old (53.34% of the total survey population), and the industry and job types are also widely distributed (**Table 1**).

Scale Design

The scales used in this study are mainly derived from mature scales in the academic community, which have been proven to have good reliability and validity in domestic and foreign studies. All scales use the Likert 5-point scale, 1 means strongly disagree, and 5 means strongly agree. The specific measurement of each variable is as follows.

(1) The independent variable is the dynamic work environment. Using the 3-item scale developed by De Hoogh et al. (2005), the measurement items include "To what extent do you agree that your work environment is very challenging?," "To what extent do you agree that your work environment is full of changes?" and "To what extent do you agree that your work environment provides many opportunities for change?". In this study, the Alpha value is 0.893,and the KMO value is 0.876.

(2) The dependent variable is innovative performance. A 10-item scale designed by Janssen (2000), including "I will provide new ideas to improve the current situation," "I will actively support innovative ideas," "I can transform innovative ideas into reality application" etc. In this study, the Alpha value is 0.903, and the KMO value is 0.887.

(3) The mediating variable is job crafting. Using Leana et al. (2009) individual job crafting of single-dimensional scale, the scale contains 6 items, such as "I will independently introduce new methods to improve work," "I will introduce new tasks that I think are more suitable for my skills or interests" etc. In this study, the Alpha value is 0.950, and the KMO value is 0.898.

(4) The moderating variable is voice behavior, including two dimensions: promotive voice behavior and prohibitive voice behavior. Adopting Liang et al. (2012) and

Lin and Johnson (2015) who develop a voice behavior scale, including promotive and prohibitive voice items. Among them, the promotive voice behavior has 5 items, such as "I actively put forward a new plan that will benefit the company," "I actively put forward suggestions to improve the company's work procedures," etc. The Alpha value is 0.878, and the KMO value is 0.813. Prohibitive voice behavior has 6 items, such as "I actively report to the leaders the incoordination problems in the work," "I dare to point out the outdated and inefficient rules and regulations in the company," etc. The Alpha value is 0.927, and the KMO value is 0.835.

DATA ANALYSIS AND RESULTS

Confirmatory Factor Analysis

In order to ensure that there is a good discrimination validity between the aspects involved in this study, confirmatory factor analysis is used to analyze the competition model on the discrimination effect of dynamic work environment, job crafting, innovative performance, promotive and prohibitive voice behavior. The degree was tested. The results are shown in **Table 2**. The fitting indicators of the five-factor model are all within the range of the reference standard, and the critical ratio ($\chi 2/df$) is the smallest, which is better than other models, indicating that the five constructs involved in this study have good discrimination validity.

Regression Analysis

This paper uses SPSS to construct a regression model of dynamic work environment and employees' innovative performance, and conducts regression tests. The results show that the dynamic work environment has a significant positive impact on employees' innovative performance ($\beta = 0.463$, $P < 0.001$). The hypothesis H1 is supported.

Analysis of the Mediating Effect of Job Crafting

This study used Bootstrap sampling inspection method, set a significance level of 0.05, and sampled 5,000 times to test the mediating effect of job crafting in the impact of dynamic work environment on employees' innovative performance. The results show that the dynamic work environment can significantly positively affect job crafting ($\beta = 0.305$, $P < 0.001$), and job crafting can significantly positively affect innovative performance ($\beta = 0.684$, $P < 0.001$). The indirect effect value of dynamic work environment that affects individual innovative performance through job crafting is 0.136, $P < 0.001$, and the 95% confidence interval is [0.180,0.394], excluding 0. The hypothesis H2 is supported.

TABLE 2 | Confirmatory factor analysis results.

Construct	Fitness index						
	χ 2/df	GFI	RMSEA	RMR	CFI	NFI	TLI
Five-factor model	2.034	0.959	0.070	0.027	0.979	0.960	0.964
Four-factor model	2.605	0.919	0.056	0.039	0.940	0.906	0.923
Three-factor model	2.905	0.931	0.054	0.048	0.939	0.932	0.930
Two-factor model	3.234	0.826	0.063	0.046	0.875	0.898	0.878
Single-factor model	4.313	0.805	0.071	0.052	0.764	0.785	0.752

Analysis of the Moderating Effect of Voice Behavior

Further, in order to test the moderating effect of voice behavior, the promotive voice behavior, prohibitive voice behavior, and dynamic work environment are first centrally processed, and the interactive items of promotive voice behavior and dynamic work environment are constructed. As well as the interaction terms of prohibitive voice behavior and dynamic work environment are constructed, they are put into the model for testing. The results show that after controlling for the main effects of promotive voice behavior and dynamic work environment, the interaction item of promotive voice behavior and dynamic work environment has a significant positive impact on job crafting ($\beta = 0.490$, $P < 0.001$), indicating hypothesis H3a is supported; After controlling the main effects of prohibitive voice behavior and dynamic work environment, the interaction term of prohibitive voice behavior and dynamic work environment also has a significant positive effect on job crafting ($\beta = 0.316$, $P < 0.001$), which shows that the hypothesis H3b is supported.

Finally, a moderated mediation model is constructed with job crafting as the mediating variable and voice behavior as the moderating variable. In this study, the average value of employees' voice behavior plus or minus one standard deviation was used to select high and low values. Under the high-level of employees' promotive voice behavior, the indirect effect of the dynamic work environment through job crafting is significant, but under the low-level of employees' promotive behavior, the indirect effect of the dynamic work environment through job crafting is not significant. From the overall analysis, the difference in indirect effects under the two conditions is significant. So, the hypothesis H4a is supported. In the same way, the hypothesis H4b is also supported. In addition, this paper examines the results of the product of path coefficients. The results of data analysis show that when employees have promotive voice behavior, the indirect effects of dynamic work environment and innovative performance are significant, the moderated mediating effect index is 0.308, and the 95% confidence interval is [0.182, 0.435]. The results of the analysis support that the employees' promotive voice behavior has a moderating effect on the process of dynamic work environment-job crafting-innovative performance. That is, the higher the employees' promotive voice behavior, the stronger the mediating role of job crafting in the dynamic work environment and innovation performance. Therefore, the hypothesis H4a is supported. When employees have prohibitive voice behavior, the indirect effects of dynamic work environment and innovative performance

are significant, the moderated mediating effect index is 0.292, and the 95% confidence interval is [0.185, 0.410]. The result of the analysis support that employees' prohibitive voice behaviors has a moderating effect on the process of dynamic work environment-job crafting-innovative performance. That is, the higher the employees' prohibitive voice behaviors, the stronger the mediating role of job crafting in the dynamic work environment and innovation performance. Therefore, the hypothesis H4b is supported.

DISCUSSION

This research focuses on the analysis of the mediating mechanism and boundary conditions of the dynamic work environment affecting the employees' innovative performance. It specifically analyzes the relationship between the dynamic work environment and employees' innovative performance with job crafting as the mediator and voice behavior as the moderator. Through theoretical research and the empirical research such as SPSS and Amos, the research hypothesis and model construction have been supported. There are also several discussions.

(1) The dynamic work environment has a positive effect on employees' innovative performance. The dynamic work environment is a realistic situation that employees have to face. In particular, the COVID-19 has made every individual, every organization, and even every country deeply aware of the uncertainty, complexity and dynamics of their environment (Song et al., 2021). In a dynamic work environment, excellent employees are an important factor in promoting the development of an enterprise. The results of this study support the positive effect of a dynamic work environment on employees' innovative performance. It can be seen that environmental uncertainty is not only a decisive factor that influences organizations on gaining competitive advantage and improving organizational performance, but also brings challenges and opportunities to employees. Employees actively capture opportunities brought by the environment, actively anticipate and respond to challenges, integrate and coordinate job knowledge, and maintain their own competitive advantages (Jacquier-Roux and Paraponaris, 2012). Those employees who can quickly upgrade and adapt to the dynamic environment will be able to fully grasp the current state of the environment, accurately understand the components of the current environment, have a clear judgment on the development trend of innovative activities, and be able to make correct decisions and behaviors. Ultimately, it will improve the innovation performance of employees. Therefore, in the relationship between dynamic work environment and innovative performance, employees should form a good mapping relationship with the dynamic work environment. In a dynamic work environment, employees must not only objectively analyze the challenges and opportunities in innovation activities, but also continuously upgrade themselves to achieve higher performance. Based on this, this research believes that a dynamic work environment will motivate employees to re-examine themselves and the work environment they face, remain vigilant and sensitive to innovation opportunities, proactively respond to environmental challenges, continuously improve their dynamic thinking and strategic decision-making capabilities, which plays a role of instruction and guidance for the improvement of employees' innovation performance. These findings are consistent with the results of Baron and Tang (2011) and Deng et al. (2019).

(2) Job crafting is an effective way for employees to cope with the dynamic work environment. The results of this study support that job crafting can mediate the positive relationship between dynamic work environment and innovative performance. The results indicate that the impact of dynamic work environment on innovative performance does not occur directly, but requires the mediating effect of job crafting. Logically, this is consistent with the fact that external environmental factors cannot directly affect organizational performance to play a positive role. Just as external environmental factors need to rely on a series of management behaviors of the organization leader to indirectly affect organizational performance. The work environment's impact on employees is not direct, but requires a series of actions by employees to have an impact on their performance, which is in line with the "environment-behavior-performance" research paradigm. This finding is consistent with the research results of Li and Atuahene-Gima (2001). It can be said that if there is no positive role played by job crafting, even if the dynamic work environment provides employees with potential opportunities, employees will not be able to make effective use of them, and therefore, it will not improve their innovative performance. Based on this, this research believes that between the dynamic work environment and innovation performance, job crafting acts like an "engine" and a "bridge," playing a transformation and driving role, and is an effective way for employees to cope with the dynamic work environment. At the same time, it also shows that the dynamic work environment has contextualized characteristics of the influence mechanism of employees' innovation performance. This empirical result also responds to the current debate that "environment-performance" is not a simple linear relationship (Lumpkin and Dess, 2001), and is an affirmative answer to the current research argument that "environmental impact on performance is a complex process."

(3) Voice behavior is the internal motivation for employees to actively respond to changes. The results of this study show that employees' promotive and prohibitive voice behaviors both play a positive role in moderating the relationship between the dynamic work environment and job crafting. Subsequently, the research results further support the moderated mediation model. The interaction between the dynamic work environment and the employees' promotive

voice behavior has an impact on employees' innovative performance through the mediating effect of job crafting. The interaction between the dynamic work environment and employees' prohibitive voice behaviors also affects employees' innovative performance through the mediating effect of job crafting. Based on this, this study believes that voice behavior is the internal motivation for employees to take active countermeasures when faced with a dynamic work environment. Whether it is promotive or prohibitive voice behavior, it can play a strengthening role.

IMPLICATIONS

The results of this study provide important implications.

(1) Both organizations and individuals should actively adapt to the dynamic work environment and inspire their own vitality. It is absolutely not a bad thing that organizations and individuals should pay attention to the dynamic work environment. On the contrary, it may activate the organization and individuals, and prompt individuals to actively make changes to improve innovative performance. Especially when employees are facing greater work pressure, they are in the purpose of protecting their own resources, and they will put forward suggestions that are beneficial to the work, showing more behaviors of seeking resources and less behaviors of reducing requirements. Therefore, when faced with a dynamic work environment, organizations should guide employees to objectively analyze and predict the dynamics and complexity of the work environment. First, the organization must allow employees to fully perceive opportunities and provide them with adequate organizational support to help them tap and use the challenges and opportunities in the environment. Second, organizations should encourage employees to grow and develop independently, give them more space for autonomy, make employees feel self-satisfied and respected, and make work and personal interests more consistent. In this way, employees will show more challenging behaviors and proactive personality, so as to be more proactive in "self-upgrading" to achieve the improvement of innovation performance. In addition, organizations and individuals need to take a long-term view and enhance their environmental sensitivity and adaptability. Although the cultivation and maintenance of these capabilities may require a certain cost, compared with their potential performance, the benefits far exceed the cost.

(2) Organizations must fully understand the importance of job crafting and encourage employees to take the initiative in job crafting. One of the ways to effectively deal with the dynamic work environment is to craft job. Therefore, organizations should make full use of the situation, employees, and job characteristics to allow employees to perceive more opportunities for job crafting, actively adjust work content and relationship boundaries, actively seek resources and challenging work, and reduce inhibitory work requirements. Organizations should give employees appropriate work autonomy and decision-making freedom to motivate employees to implement job crafting, so as to better complete their work tasks. In the work arrangement and design, the organization should enhance the matching of people-work, improve work input and efficiency, and provide employees with resources and substantive assistance, reduce the obstacles they encounter in the process of job crafting, and stimulate innovative behavior. At the same time, organizations must actively meet the needs of employees for job crafting and interpersonal communication, cultivate and train employees' proactive personality and environmental adaptability, encourage them to actively learn and adapt to the dynamics and complexities faced in work, and improve their response to changes and the ability to solve problems. Organizations also need to actively create a good work environment, such as environmental pressure, leadership style and methods, and organizational policies, to help employees establish organizational identity and role recognition as soon as possible, so as to better engage in work and improve innovation performance. In addition, the organization should provide timely feedback on the behavior and results of employees' job crafting, and actively encourage, recognize and guide them to form a virtuous circle.

(3) Organizations should improve the management system and mechanism for employees' voice behavior, and establish a smooth communication channel for employees' voice behavior. Firstly, it is necessary to establish an organizational mechanism for employees to participate in decision-making, broaden the channels for voice behavior, plan the path of voice behavior, and improve the voice behavior process, so as to ensure the normalization and implementation of voice behavior to a greater extent. Secondly, organizations must reform their organizational structure, strive to implement flat management, ensure the effectiveness, timeliness and smoothness of participation in the system. They must also give full tolerance and respect to voice behaviors. Managers are required to give employees feedback in a timely manner, and adopt reasonable and workable voice. Thirdly, it is necessary to create an open, tolerant and innovative cultural atmosphere, and increase the enthusiasm of employees to make voice behavior. Managers should strive to cultivate non-employment relationships with employees. The basis of employees' voice behavior is the mutual trust and effective communication between managers and employees, which reduces the psychological barriers for employees to participate in voice behavior. With this, employees can actively put forward new ideas and innovative suggestions. In addition, organizations can consider including the voice behavior into employee performance appraisal indicators, and develop a positive and effective incentive system of voice behavior, so as to encourage employees to continuously improve the content and the quality of their voice behavior, and put forward more targeted voice with commercial value.

CONCLUSION

Studies show that the dynamic work environment has a significant positive impact on employees' innovative performance, and job crafting plays a mediating role in the relationship between the two. In addition, voice behavior positively moderate the relationship between dynamic work environment and job crafting, and the indirect relationship between dynamic work environment and innovative performance through job crafting.

This research still has certain limitations. Future research can be considered from the following aspects. First of all, this study only carried out research based on the research paradigm of "environment-behavior-performance". It did not consider the impact of the dynamic work environment on employees' other work attitudes and behaviors, nor did it consider other possible influence mechanisms. Future research can try to explore the different impacts of the dynamic work environment and its impact mechanism, so as to further expand and enrich the research on the impact of the dynamic work environment on employees' work attitudes and behaviors. For example, studies have shown that in a dynamic work environment, organizational identity, work commitment, feedback seeking behavior, etc., have an impact on employees' work attitudes and behaviors, which in turn will affect employees' innovation performance. Second, this study considers the moderating effect of employees' voice behavior, but this is only one of the boundary conditions that may affect whether employees will actively their job crafting in the face of a dynamic work environment. In fact, there are more factors that will affect the process of action. For example, supervisor support, leadership-member exchange relationships, and employee uncertainty tolerance, etc., may all have an impact on the relationship between the dynamic work environment and innovative performance. Future research can continue to explore the boundary conditions of the dynamic work environment affecting the specific process of innovative performance. For example, with the normalization of the epidemic, there may be new changes in the psychological mood and behavior of employees in the post-epidemic era. At the same time, with the increase in work goals and work complexity, it may be more difficult for employees to manage their own negative emotions. At this time, employees need more organizational context power to provide them with emotional assistance, so as to enhance the positive effects of situational modification and cognitive change. Therefore, future research can focus on the influence mechanism of variables such as organizational context.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of Wuhan University of Science and Technology. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

JW distributed the work done in the project, searched the background materials, designed the analytical characterization, and empirical study frame and has done the critical revision and editing.

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Financial Performance Under the Influence of the Coronavirus Disease 2019: Effects of Strategic Flexibility and Environmental Dynamics in Big Data Capability

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This study draws on the dynamic capabilities view and the firm's big data capability (BDC) in the new economic environment. It constructs an adjusted intermediary model to study the mechanism of BDC, strategic flexibility, and environmental dynamic affecting financial performance. We find that strategic flexibility plays an intermediary role in the "Converse-U" relationship between BDC and financial performance. Environmental dynamics adjust the relationship between BDC and financial performance positively and smooth the "Converse-U" relationship. The findings suggest building and managing BDC, combining BDC with the management process, and achieving continuous financial performance improvement in a dynamic environment. The paper also puts forward the nonlinear hypothesis, discusses the "Converse-U" relationship between BDC and enterprise financial performance in the Chinese context of digital economy explosion and growth, and considers the intermediary mechanism of strategic flexibility and the regulatory effect of environmental dynamics.

Keywords: COVID-19 pandemic, big data capability, strategic flexibility, financial performance, environmental psychological dynamics

INTRODUCTION

The large-scale outbreak of coronavirus disease 2019 (COVID-19) in early 2020 posed a huge challenge to the survival and development of enterprises. In the first quarter of that year, GDP decreased by 6.8% year-on-year, and industry, investment, and consumption indicators dropped significantly. To eliminate the dilemma of delayed resumption of work and plummeting income, most enterprises have to speed up digital transformation and rely on Internet technology and big data application to upgrade the business structure. Technological progress has promoted online digitisation and intelligence, and enterprises have carried out informatisation reform and industrialisation transformation with the assistance of cloud computing and big data platforms. In the new context of the explosive growth of the digital economy, the realisation of the enterprises' financial performance depends on enterprises that can successfully implement the digital transformation and big data capability (BDC) building, so the BDC directly affects the achieving form of enterprises financial performance (Patrick and Adamantia, 2017). As one of the dynamic capabilities for businesses to grow and gain sustainable competitive advantages, what is the

impact of BDC on financial performance? The research on this issue has increasingly been brought into focus by academic and business circles (Yu, 2018). Although some relevant researches on the relationship between BDC and financial performance have been constructed, there are still some puzzles to be solved.

On the one hand, it has been suggested that enterprises with BDC can quickly iterate on products and services, achieve personalised marketing methods, and complete pricing systems, thus contributing to the enhancement of enterprises' the financial performance (Akter and Wamba, 2016; Gupta and George, 2016; Yaqoob et al., 2016; Côrte-Real et al., 2017; Mikalef et al., 2019). Because the enterprise's management ability and digital technology fail to realise coordinated development, the digital technology cannot integrate with the original resources and business, thus inhibiting the improvement of enterprise financial performance (Vidgen et al., 2017; Guoqing et al., 2018). Two main reasons for the inconsistency of research conclusions and the ambiguity of explanation are as follows: First, there may not be a simple linear relationship between BDC and financial performance. Previous studies were based on the fact of a linear relationship between the two, and this assumption may be the reason for the inconsistency of research conclusions; Second, previous research which are mainly focused on the direct impact of BDC on financial performance, possibly ignoring the different mechanisms and contextual factors, exist in the relationship between BDC and financial performance, so it is urgent to explore the intermediary variables and adjustment mechanisms between the two.

According to dynamic capability theory, as one of the significant dynamic capabilities in the digital economy, BDC has a lasting and profound impact on enterprise strategy realisation and financial performance advance (Teece, 2017). Especially against the backdrop of COVID-19, BDC is playing an increasingly significant role in enhancing the resilience of supply chains, improving the level of digital application, and resolving the operational and financial crisis. BDC is considered a vital factor affecting strategic flexibility (Han and Zhang, 2021). Strategic flexibility can enhance the ability to cope with environmental changes and maintain high agility and flexible allocation of resources so that enterprises can quickly respond to varieties and then coordinate the elements when facing the risks arising from environmental changes, thus maintaining a long-term competitive advantage. Strategic flexibility has become an indispensable condition for an enterprise's success (Correa et al., 1994; Kaufman, 2015; Raguseo and Vitari, 2018). Thus, great importance is attached to strategic flexibility by managers. However, in the context of China, the mechanism of BDC on strategic flexibility has not been dived into, and research on the relationship between BDC and financial performance from the perspective of strategic flexibility is even more absent. The core connotation of BDC includes the capability of enterprises to apply big data technology to integrate resources, realise internal process optimisation and external competitive trend prediction, and adapt to environmental changes. Enterprises with moderate BDC can filtrate, analyse, and mine a large number of complex and heterogeneous data through big data technology to obtain data value and continuous competitive advantage.

In contrast, insufficient BDC, like deficient ability to integrate, analyse, and utilise big data resources, will make it difficult for enterprises to capture potential business opportunities, which is not conducive to forming strategic flexibility. Combining with the existing theories and researches, this paper holds that strategic flexibility is an important intermediary mechanism of BDC affecting financial performance. Furthermore, the process of the enterprise BDC acting on financial performance is affected by complex contextual factors. When the environmental dynamics are low, the enterprise's market demand, technical changes, and institutional environment are stable and predictable. However, in the highly dynamic environment, just like the current epidemic environment, a series of domestic and foreign environmental uncertainties, including the decline and delay of consumer demand, is increasing. Thus, the risk of business interruption and operation crisis faced by the enterprise is also rising (Chen and Liu, 2020). Owing to the unpredictability of the market, technology, and institutional environment, more resources need to be reserved by enterprises to deal with external shocks (Duanmu et al., 2018). Enterprises with high BDC can better brace themselves for a period of upheaval based on in-depth analysis of internal and external data. By rapidly mobilising and allocating resources to adjust products and services ahead of competitors (Vela-Jiménez et al., 2014), enterprises can seize the market opportunity to quickly launch new products or services that cater for customers and, finally, conduce to the acquisition of a lasting competitive advantage, thereby improving the financial efficiency (Yunfeng et al., 2019). Therefore, environmental dynamics will be considered a scenario condition in studying the relationship between BDC and financial performance.

The contribution of this research to the current mainly includes the following three points: First of all, this paper puts forward the nonlinear hypothesis, discusses the "Converse-U" relationship between BDC and enterprise financial performance, which offers a possibility of researching the relationship between the two; In addition, this paper explores the mechanism of BDC affecting performance in the Chinese context of digital economy explosion and growth and considers the intermediary mechanism of strategic flexibility and the regulatory effect of environmental dynamics. Finally, the research emphasises the value of BDC to organisation management under the background of the post-epidemic era, and the research conclusion has a significant value for optimising enterprise BDC, constructing strategic flexibility and booting enterprise performance.

THEORETICAL BACKGROUND AND RESEARCH MODEL

Big Data Capability and Financial Performance

Financial performance refers to the cost control and profitability of an enterprise based on existing business operations. BDC can realise more accurate identification of customer needs, the faster segment of the target market, and product iterations through personalised marketing, accordingly showing the better

financial performance (Akter et al., 2016). Dynamic capability theory suggests that enterprises should enhance the alignment with a dynamic environment to quickly respond to changes in the market and external technology (Adner and Helfat, 2003). The theory emphasises that enterprises can allocate and update existing resources according to needs in the dynamic environment and quickly deal with market and business environment changes. As one of the dynamic capabilities, BDC plays a crucial role in all aspects of enterprise management, inevitably affecting financial performance.

Current connotation understanding and dimension classification of BDC is very diversified. Wikipedia defines big data as a collection of data that cannot be captured and managed by regular software tools over time (Lynch, 2008). As the core capability in the digital economy, research on BDC is carried out in many fields. In the perspective of the technology field, BDC is considered to exist in big data acquisition, integration, analysis, and visualisation technology (Wang and Hajli, 2017). Through the collaboration of big data technology and relevant infrastructure, valuable decision-making and dynamic management capability can be obtained (Wang et al., 2017). From an organisational perspective, a system based on BDC is constructed and applied to management practice based on viewpoints on organisational structure, organisational culture, and organisational knowledge (Corte-Real et al., 2017). User heterogeneity is proposed based on user cognition (Orlikowski, 2007). It is pointed that human, technology, and organisation, together, make up the relational ontology and form dynamic BDC from environmental interaction perspective (Orlikowski and Scott, 2008; Sivarajah et al., 2016). Researchers in strategic management have developed the BDC scale (Cecez-Kecmanovic et al., 2014; Akter et al., 2016; Wamba et al., 2017), which lays a foundation for empirical research from the resource-based view and dynamic capability view (Ayabakan et al., 2017; Nan et al., 2018). In this paper, it is considered that BDC is the dynamic capability of enterprises to filtrate, integrate, reconstruct, and utilise massive internal and external data resources and transform them into unique advantages to support enterprises' strategic transformation and operation decisions in the changing environment (Rijmenam et al., 2018). BDC is a distinct and pivotal resource in the digital economy and a dynamic capability for practice. This dynamic feature integrates internal and external resources to achieve original competitive advantages (Caifeng et al., 2019). Weihong et al. (2016) divide BDC into three dimensions: big data acquisition integration capability, big data in-depth analysis capability and big data insight, and prediction capability. Among them, big data acquisition integration capability emphasises the ability of enterprises to collect, integrate, and continuously update internal and external big data resources. Big data in-depth analysis capability requires enterprises to analyse and mine massive data and convert them into unique advantages. Big data insight and prediction capability refers to monitoring changes in the market environment and predicting future trends.

As the new functioning capital and vital resource of enterprises, the strategic significance of big data lies in the professional processing of massive data, providing necessary real-time information for enterprise decision-making, realising accurate prediction of customer and market demand, and maintaining the long-term competitive advantage of the enterprises. It is ultimately reflected in improving financial performance, including profit growth, business development, and advance in return on assets (Harris and Davenport, 2007; Barton and Court, 2012; Chen et al., 2015). Above all, big data resources include internal operation and external environmental data of the enterprise and non-data resources such as infrastructure, human resources, and technical resources. Enterprises utilise diversified data platforms and complete infrastructure to achieve resource integration, filter, store, process, and professional value from massive data with complex structures, and guide internal business and external market strategies, enhancing enterprise market value. Wamba et al. (2017) confirm that BDC directly affects financial performance and market performance. But excessive big data resources and integration often make enterprises pay more attention to emerging resources and ignore the adaptability of original resources.

Next, the analysis capability is to extract value from huge amounts of data and gain new insights. Surveys of executives find that the higher-performing organisations use five times more often than lower-performing organisations (Hitt et al., 1998). Big data analysis empowers enterprises to know about product operation and user reviews to optimise user experience, maintain customers, and analyse internal business processes and optimal directions based on large amounts of data. The more professional analysts and technologies are, the more sensitive they will be to discovering the potential value of data and the connection with the real market. The more sensitive the company will be to capture possible business opportunities, a powerful guarantee for corporate economic growth. However, an excessive analysis may break away from the actual business's needs and increase the enterprise's decision-making cost. At the same time, excessive superstition on data can easily lead to the misunderstanding of "excessive specialisation" and reduce the service value of BDC to the enterprise.

The last, big data insight and prediction capability enable companies to realise real-time insights into the environment and market demand, foresee changes in the environment, and then adjust production plans and service processes promptly, which is beneficial to expand the market and increase revenue growth. Raguseo and Vitari (2018) also point out that big data analysis help enterprises create greater business value, thereby driving the growth of company performance. However, relying too much on big data insight and prediction capability will neglect the impact of other factors such as policy environment on the development of enterprises, which is ultimately detrimental to the improvement of enterprise performance.

Combined with the above analysis, BDC help enterprises integrate big data resources and effectively deploy technology and talent for data analysis to realise internal process optimisation and external competitive trend prediction, forming valuable insights and generating insights. However, excessive BDC often leads to higher investment, resulting in the "IT capability paradox" trap, leading to the decline of enterprise financial performance and deviation from the organisation's original

goal. Therefore, BDC and enterprise financial performance may present the nonlinear "Converse-U" relationship. Based on the construct dimension of BDC, it can comprehensively and accurately reflect the financial performance as a whole, therefore this paper puts forward the following research assumption:

H1. BDC has a "Converse-U" effect on financial performance

Big Data Capability and Strategic Flexibility

Strategic flexibility is a dynamic capability transformation process in the view of the organisational concept. It is a consistent capability that matches the degree of environmental changes based on the original strategy (Li et al., 2010; Nadkarni and Herrmann, 2010), realising the response and dynamic adjustment of the organisation to environmental changes, and achieving the high performance of the whole organisation (Weihong et al., 2013; Farnese et al., 2016). According to characteristics of strategic flexibility, its dimension is divided into preemptive flexibility and response flexibility (Hai and Dong, 2010). On the other hand, according to dynamic capability theory, strategic flexibility dimension is divided into capability flexibility and resource flexibility (Matthyssens et al., 2005; Tennan et al., 2010). Lastly, according to resource utilisation and process allocation, it can be divided into resource flexibility and coordination flexibility (Zhengang et al., 2021). Researches have been studied on the relationship between BDC and strategic flexibility from data empowerment (Ziqing, 2021) and the digital economy (Katsuhiko and Michael, 2004). According to Tennan et al. (2010), this paper studies the mechanism of BDC on strategic flexibility from two aspects of resource flexibility and capability flexibility.

According to the dynamic capability view, in the dynamic changing market, technology and institutional environment, the limited nature of the enterprise's resources can hardly meet the changing demand of the market, and the strategic flexibility can quickly allocate its resources or seek new resources to benefit the enterprise (Sanchez, 1997). As a dynamic capability, BDC props enterprises to integrate internal and external resources, deeply analyse the integrated environment, and formulate specific strategies (Weihong et al., 2016). Strategic flexibility, as a potential capability including capability flexibility and resource flexibility, enables firms to adapt quickly to dynamic environments when faced with rapid changes in internal and external environments (Matthyssens et al., 2005; Tennan et al., 2010). Capability flexibility refers to the ability to discover new resources and allocate them reasonably in the face of environmental uncertainty to maximise the utilisation of resources (Cingöz and Akdoðan, 2013). Compared with other competitors, enterprises with high flexibility can better identify and grasp opportunities in a rapidly changing environment, complete the updating and transformation of relevant resources, timely adjust enterprise strategies, and then create advantages to boost economic benefits. Resource flexibility is low-cost and rapid scheduling of resources to meet consumers and the market (Beard, 1984). Enterprises with high resource flexibility can actualise a high sharing of resources, which can also create value for enterprises (Han and Zhang, 2021). Resource flexibility enables the enterprise to transform from one resource to another at low cost, enriching the resource combination and constructing a unique competitive advantage, thereby improving enterprise financial performance.

Based on the above analysis, BDC is conducive to the adaptability of organisations in an uncertain environment, promoting the improvement of capability flexibility and resource flexibility, and further enhancing financial performance. However, excessive BDC, such as paying too much emphasis on big data resource construction and deployment of big data analysis technology, may lead to the failure of the effective integration of big data capabilities with the original business, affecting the construction of strategic flexibility. Therefore, the following research assumption is proposed:

H2. BDC has a "Converse-U" effect on strategic flexibility.

Strategic Flexibility's Mediating Effect

The direction and extent of impact between BDC and financial performance can be measured directly, but the relationship can be a complex feedback system. As an important dynamic capability of an organisation, BDC adapts to the dynamic environment based on organisational perspective and forms strategic flexibility. Strategic flexibility is considered in the research process, which itself is also a process of strategic flexibility formation and will affect enterprise financial performance. In this study, BDC affects strategic flexibility and, thus, financial performance. Therefore, the following research assumption is proposed:

H3. Strategic flexibility plays an intermediary role in the "Converse-U" relationship between BDC and financial performance.

Environmental Dynamics' Moderating Effect

Environmental dynamics are the speed and unpredictability of environmental change (Lazonick and Prencipe, 2008). Based on the market and technology perspective, studies have been carried out on technological and external market environment dynamics (Su, 2011; Sainio et al., 2012). In contrast, less attention has been paid to the influence of institutional environment dynamics. The institutional environment significantly impacts development strategy, speed, and scale (Yingwei et al., 2019). A loose and favourable institutional environment is more conducive to BDC development and the consolidation of competitive advantages (Zhang et al., 2020). Therefore, in this paper, environmental dynamics includes three dimensions: technological environment dynamics, market environment dynamics, and institutional environment dynamics. In the context of the dynamic environment, strategic flexibility is a key factor affecting organisational performance. Strategic flexibility improves internal communication efficiency and strategic execution ability, thus positively affecting financial performance. Wamba et al. (2017) confirm that environmental dynamics regulate the relationship between organisational BDC

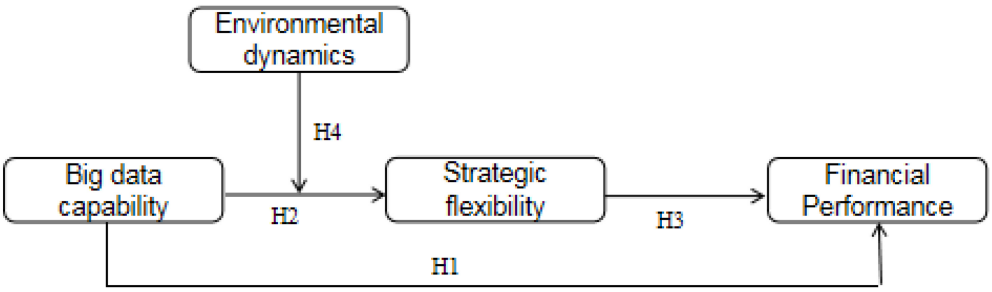

FIGURE 1 | Research model.

and supply chain agility. Based on a double marginalised perspective, environmental dynamics can positively regulate the relationship between environmental and financial performance (Kim et al., 2011). In a highly dynamic environment, enterprises rely more on the advantages of deep analysis, trend insight, and demand prediction brought by big data capabilities to maintain corporate performance at a higher level. Based on the above analysis, the following assumption is proposed:

> **H4.** Environment dynamics plays a positive role in the "Converse-U" relationship between BDC and strategic flexibility. Under high environmental dynamics, the "Converse-U" impact of BDC on strategic flexibility is weaker.

According to the previous literature, this paper constructs a hypothetical model of the effect mechanism of BDC on financial performance, as shown in **Figure 1**.

RESEARCH METHODS

Research Sample and Process

Our research uses questionnaires in 10 provinces: Shanghai, Beijing, Jiangsu, Anhui, Zhejiang, Shanxi, Liaoning, Gansu, Chongqing, and Guizhou. The industries were distributed in the fields of telecommunication, energy, high-tech, and consulting services. We avoided possible common method variance, and the samples were paired to collect data from different sources. The head of the enterprise big data department (if there was no big data department, the informatisation department could be responsible for it) reported the BDC, strategic flexibility, and environmental dynamics. The financial executive reported the financial performance. The big data manager and the financial executive formed a set of research questionnaires after pairing. The questionnaire included an electronic questionnaire and an on-site questionnaire. For the questionnaires filled on-site, the identity of the interviewees would be confirmed by the General Manager's Office. Then, the questionnaire data of big data managers and financial executives needed to be collected simultaneously to directly match into a set of questionnaires. Electronic questionnaires were mainly aimed at the situation that managers cannot be present simultaneously. The General Manager Office was requested to provide names and email addresses of the two managers, and the investigators sent the questionnaire to the manager, who was required to fill in the questionnaire and return it. Throughout the survey, it was repeatedly emphasised that the survey is voluntary to avoid unnecessary deviations.

In this study, 400 big data department manager questionnaires and 400 financial department executive questionnaires were distributed. Three hundred two questionnaires were collected from big data department managers, with a recovery rate of 75.5%; 310 financial department executives' questionnaires were collected, with a recovery rate of 77.5%. After eliminating the low-quality questionnaires that did not meet the research requirements, 274 questionnaires that finally met the research design were collected, with an effective rate of 68.5%. Based on the analysis of valid samples, the statistical data are as follows: (1) The nature of organisation: the largest number of private enterprises accounts for 51.1%, local state-owned enterprises account for 26.3%, Hong Kong, Macao and Taiwan independence assets and holding enterprises account for similar proportion with foreign-funded enterprises. The overall distribution is relatively balanced, with a certain extent of universality. (2) Organisation type: information transmission, software and technology services industries account for the highest proportion of 35.8, the manufacturing industry is 29.9%, and other industries are not much different. (3) Organisation scale: this research takes the number of employees as the index to measure the organisation scale, enterprises with 301–1,000 employees account for 35.8%, enterprises with 300 employees and below account for 24.8%, and enterprises with 1,001–2,000 account for 17.5%. The overall distribution is balanced and has certain representativeness. (4) Annual sales: 33.2% of enterprises with sales of more than 300 million, 26.3% of enterprises with sales between 30 million and 100 million, and the others with similar sales. The specific sample composition is shown in **Table 1**.

Variable Measurement

To ensure the effective measurement of the research model, firstly, the scale selected in this study comes from the mature scale of the top journals at home and abroad. Graduate students with excellent English proficiency are invited to translate the English scale to ensure quality. For items in doubt, experts in the same field are invited to confirm again, and the initial version of the questionnaire is formed. Secondly, other scholars in the same field are invited to back-translate the original questionnaire.

TABLE 1 | Descriptive statistics of the sample and respondents.

Factor	Classification	Sample (*N* = 274)	Proportion (%)
Industry	Mining, construction	13	4.7
	Electricity, gas and water production and supply industries	6	2.2
	Transportation, warehousing and postal services	34	12.4
	Financial industry	15	5.5
	Agriculture, forestry, animal husbandry and fishery	4	1.5
	Wholesale and retail trade	12	4.4
	Information transmission, software and technology services	98	35.8
	Manufacturing industry	82	29.9
	Accommodation and catering	4	1.5
	Other	6	2.2
Firm size (number of employees)	<300	68	24.8
	301–1,000	98	35.8
	1,001–2,000	48	17.5
	2,001–3,000	14	5.1
Annual sales	<30 million	41	15.0
	30–100 million	72	26.3
	100–200 million	42	15.3
	200–300 million	28	10.2
	>300 million	91	33.2
Ownership	Central enterprises (including state-owned holding)	27	9.9
	Local state-owned enterprises (including state-owned holding)	72	26.3
	Private enterprises (including private holding)	140	51.1
	Hong Kong, Macao and Taiwan independence assets and holding enterprises	16	5.8
	Wholly foreign-owned and controlled enterprises	17	6.2
	Other	2	0.7

Industrial division refers to National Economy Industry Classification.

The back-translated English questionnaire is compared with the original questionnaire to further modify the existing problems. Thirdly, five executives are invited to conduct a pre-search to discuss and revise the unclear and ambiguous questions. Finally, the questionnaire for conducting a large sample survey is confirmed. The Likert Scale measures variables (1 = totally disagree; 2 = disagree; 3 = uncertain; 4 = agree; 5 = totally agree).

(1) Big Data Capability (BDC). This paper draws on the situation scale developed by Kim et al. (2011) and Weihong et al. (2016), including three dimensions: big data acquisition integration capability, big data in-depth analysis capability, and big data insight and prediction capability, with a total of 12 items. Among them, big data acquisition and integration capability dimension include four items, mainly referring to the scale of Kim et al. (2011), to measure the enterprise's capability of big data resources acquisition and data processing, such as "The enterprise has infrastructure related to big data, including big data support platform and business application system." Big data in-depth analysis capability dimension includes four items, mainly referring to the research of Weihong et al. (2016) and Lin and Kunnathur (2019), to measure the enterprise's ability to excavate latent value from the magnanimous data through analysis. Representative items such as "Enterprises can effectively clean and standardise massive data." Lastly, big data insight and prediction capability dimension include four items, mainly referring to the research of Gang and Min (2014) and Lin and Kunnathur (2019), to measure the real-time understanding and trend prediction capability of market and environment based on big data. Representative items include "Enterprises realise real-time insight and trend prediction on the market based on big data." In this study, the Cronbach's Alpha for the BDC scale is 0.949.

(2) Strategic flexibility. Strategic flexibility includes two dimensions: resource flexibility and capability flexibility. This paper draws on the strategic flexibility scale of Grewal and Tansuhaj (2001) and Li et al. (2010), with a total of six items, which has been widely used in the research of Chinese situation (Tennan et al., 2010). Among them, three items are used to measure the dimension of resources flexibility, and the representative items include "The difficulty and cost of enterprise resources transforming from one use to another are low." On the other hand, three items measure the dimension of capability flexibility, and the representative items include "The enterprise can identify the change of external environment and transform the use of resources." The Cronbach's Alpha for the strategic flexibility scale is 0.904.

(3) Environmental dynamics. Three dimensions consist of environmental dynamics, including market, technical, and institutional environmental dynamics. This paper draws on the scale of Jansen et al. (2006) and Jintong-Tang et al. (2010), with a total of six items. The scale has already been applied in the research of the Chinese context (Chunyan and Shuming, 2010; Wencong and Guilong, 2011; Jinfeng et al., 2019), which ensures the effectiveness of the measurement. Among them, two items measure the dynamic dimension of the market environment. The representative item includes "In the enterprise's business scope, the customer's product/service preference changes rapidly." Two items measure technical, environmental dynamics, for instance, "the technical innovation speed is fast in industry field." Two items measure the institutional environmental dynamics, the representative item includes "Governments at all levels have various assistance and policies for the enterprise's BDC building." In this study, the Cronbach's Alpha of the environmental dynamics scale was 0.856.

(4) Financial performance. Financial performance includes four dimensions: profitability, sales growth rate, customer retention, and return on investment. This paper draws on Li et al. (2010) and Akter et al. (2016). There are four items in total: "Adoption of big data

TABLE 2 | Assessment of reliability and validity of reflective constructs.

Variable	Measures	Factor loading	AVE	CR
Big data capability (BDC)	BDC1: Enterprise has infrastructure related to big data, including big data support platform and business application system, etc.	0.692	0.613	0.950
	BDC2: Enterprises can continuously obtain and update internal and external big data information in time	0.702		
	BDC3: Enterprises can quickly store and process large amounts of data	0.769		
	BDC4: Enterprises can continuously learn and update big data technology (data crawling, storage, analysis, visualisation)	0.755		
	BDC5: Enterprises can effectively clean and standardise massive data	0.748		
	BDC6: Enterprises are skilled in using technologies, tools and platforms related to distributed computing of big data (Hadoop/HPCC/Storm/Pentaho BI etc.)	0.826		
	BDC 7: Enterprises can analyse unstructured data such as text and voice in real-time	0.810		
	BDC 8: Enterprises can mine valuable information from massive customer and market information	0.779		
	BDC 9: Enterprises know and predict customer behaviour in real-time based on big data	0.823		
	BDC10: Enterprises predict the behaviour of partners and competitors based on big data	0.791		
	BDC11: Enterprises realise real-time insight and trend prediction on the market based on big data	0.812		
	BDC12: Enterprises identify business operation and development strategies based on big data	0.870		
Financial performance (FP)	FP1: Adoption of big data capability improves profitability	0.716	0.589	0.851
	FP2: Adoption of big data capability improves sales growth rate	0.724		
	FP3: Adoption of big data capability improves customer retention	0.759		
	FP4: Adoption of big data capability improves the sales growth rate	0.862		
Strategic flexibility (SF)	SF1: Difficulty and cost of enterprise resources transforming from one use to another is low	0.796	0.613	0.905
	SF2: Time of enterprise resources transforming from one use to another is less	0.762		
	SF3: Effective usable range of enterprise existing resources is relatively wide	0.753		
	SF4: Enterprise can identify the change of external environment and transform the purpose of resources	0.788		
	SF5: Enterprises are always able to allocate resources appropriately to cope with changing environments	0.775		
	SF6: Enterprise can effectively allocate resources through organisational systems and procedures according to objectives	0.823		
Environmental dynamics (ED)	ED1: In the enterprise's business scope, the customer's product/service preference changes rapidly	0.621	0.501	0.857
	ED2: Many new customers are emerging to buy enterprise products/services	0.771		
	ED3: The technical Innovation speed is fast in the industry field	0.716		
	ED4: Technological change offers great opportunities for the whole industry	0.701		
	ED5: Governments at all levels have various assistance and policies for the enterprise's BDC building	0.697		
	ED6: The enterprise has access to a variety of information about big data	0.733		
	X^2/df = 2.343, RMSEA = 0.070, IFI = 0.912, TLI = 0.902, CFI = 0.911			

capability improves customer retention" and "Adoption of big data capability improves the sales growth rate." The financial performance scale in this study has a Cronbach's alpha of 0.849.

(5) Control variables. Based on previous studies, this study selected industry type, firm size, annual sales, and ownership as control variables (Akter et al., 2016; Weihong et al., 2016). This paper sets four control variables as virtual variables, assigning different values to different types and ranges of options.

Validity and Reliability Analysis

The factor loading, average variance extraction (AVE), and composite reliability (CR) of each variable are calculated to test the scale's validity. Results show that factor loading of each item in the scale is between 0.6 and 0.9, indicating that potential variables have a strong explanatory ability to measure variables. Moreover, AVE of BDC, strategic flexibility, environmental dynamics, and financial performance is 0.613, 0.589, 0.613, and 0.501, respectively, which is higher than the critical value of 0.5. The CR of each variable is 0.950, 0.851, 0.905, and 0.857, respectively,

TABLE 3 | Analysis of confirmatory factors.

Model	X^2 (df)	X^2/df	CFI	IFI	TLI	RMSEA	SRMR
Single factor model(BDC+SF+FP+ED)	1713.823	4.897	0.737	0.739	0.716	0.119	0.094
Two-factor model(BDC+SF+FP, ED)	1296.689	3.715	0.817	0.818	0.802	0.100	0.071
Three-factor model 1(BDC, SF+FP, ED)	1096.451	3.151	0.856	0.857	0.843	0..089	0.066
Three-factor model 2(BDC+SF, FP, ED)	1013.828	2.913	0.872	0.872	0.861	0.084	0.057
Three-factor model 3(BDC+FP, SF, ED)	1115.427	3.205	0.852	0.853	0.839	0.090	0.068
Four-factor model(BDC,FP, SF, ED)	805.976	2.343	0.911	0.912	0.902	0.070	0.049

TABLE 4 | Correlation matrix of variables.

Variable	X1	X2	X3	X4	X5	X6	X7	X8
Industry	1							
Firm size	−0.147*	1						
Annual sales	−0.116	0.685**	1					
Ownership	−0.160**	−0.166**	−0.136*	1				
Big data capability	0.156**	0.221**	0.330**	−0.135*	1			
Strategic flexibility	0.146*	0.125*	0.241**	−0.096	0.784**	1		
Environmental dynamics	0.095	0.135*	0.172**	−0.035	0.473**	0.409**	1	
Financial performance	0.130*	0.136*	0.094	−0.007	0.528**	0.510**	0.383**	1
Mean value	3.672	2.533	3.204	2.745	4.1128	3.9775	4.1381	4.1451
Standard deviation	2.438	1.364	1.503	0.984	0.649	0.589	0.520	0.577

*Significance level: ***means 0.1%, **means 1%, and *means 5%.*

which is higher than the critical value of 0.8, indicating that the measurement of the four variables has satisfactory convergent validity. The intrinsic quality of the model is acceptable, as shown in **Table 2**.

To ensure the reliability and validity of the study, AMOS 23.0 statistical software is utilised to conduct confirmatory factor analysis on four variables. Six-factor combination model data are obtained by establishing different factor models composed of BDC, strategic flexibility, financial performance and environmental dynamics, and the analysis results are shown in **Table 3**. Compared with other models, the four-factor model has the best fitting effect on data. Specifically, from single-factor model to four-factor model, X^2(df) decreases from 1713.823 to 805.976, X^2/df decreases from 4.897 to 2.343, root-mean-square error of approximation (RMSEA) decreases from 0.119 to 0.070, standardized root mean square residual (SRMR) decreases from 0.094 to 0.049. The smaller values of these indexes are, the better fitting effect is. In addition, comparative fit index (CFI) increases from 0.737 to 0.911, incremental fit index (IFI) increases from 0.739 to 0.912, and tucker-lewis index (TLI) increases from 0.716 to 0.902. The closer these three indicators are to 1, the better the model is. On the whole, the fitting indexes of the four factors model are better than other models, indicating that BDC, strategic flexibility, financial performance and environmental dynamics are disparate concepts.

DATA ANALYSIS AND HYPOTHESIS TESTING

Correlation Analysis

In this paper, SPSS23.0 statistical software is used for data analysis, and the correlation analysis results of each variable are shown in **Table 4**. BDC, strategic flexibility, environmental dynamics, and financial performance are significantly positively correlated, which provides preliminary support for the follow-up study on the relationship between variables.

Hypothesis Testing

(1) Main effect testing: Hypothesis1 puts forward that the BDC has a "Converse-U" effect on financial performance. Financial performance is set as the dependent variable in the research. Four control variables, such as industry type, firm size, annual sales, and ownership, are added to the model. Then BDC's first-power term and quadratic term are added to test the hypothesis. To reduce the possibility of multiple co-linear relationships caused by nonlinear paths in the model, the quadratic term of BDC is decentralised and analysed according to the curve effect test procedure suggested by Porter et al. (1994) and Hayes and Preacher (2010). The results of hierarchical regression analysis are shown in **Table 5**. Model 2 and model 3 show that quadratic term of BDC hurts financial performance (β = -0.173, $p < 0.05$). In addition, the first-power term of BDC has a significant positive impact (β = 0.407, $p < 0.001$), indicating that BDC are positively associated with financial performance, and the relationship between two is "Converse-U," Hypothsis1 is supported.

(2) Mediating effect testing: It is assumed that strategic flexibility mediates the relationship between BDC and financial performance. According to the moderated mediation effect test method proposed by Zhonglin et al. (2004), three conditions should be met: (1) BDC is significantly correlated with financial performance, (2) BDC is significantly related to strategic flexibility, and

TABLE 5 | Regression test results of main effect and the mediating effect.

Variable		Financial performance				Strategic flexibility			
		Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Control variable	Industry type	0.038*	0.014	0.009	0.008	0.018	0.040*	0.004	0.001
	Firm size	0.069**	0.068*	0.070*	0.076*	0.082**	−0.026	−0.028	−0.026
	Annual sales	0.003*	−0.070*	−0.078**	−0.079**	−0.056*	0.116	0.011	0.006
	Ownership	0.028	0.047	0.035	0.036	0.040	−0.024***	0.004	−0.004
Independent variable	BDC		0.492***	0.407***	0.255**			0.714***	0.659***
	BDC^2			−0.173*	−0.148*				−0.112*
Mediation variable	Strategic flexibility				0.231**	0.505***			
Regression index	R^2	0.044	0.305	0.320	0.341		0.092	0.618	0.624
	Adj-R^2	0.030	0.292	0.305	0.324		0.078	0.611	0.616
	F-value	3.083	23.482	20.960	19.668		6.785	86.704	73.916

*Significance level: ***means 0.1%, **means 1%, and *means 5%.*

(3) when strategic flexibility enters into the relationship between BDC and financial performance, the relationship between BDC and financial performance is not significant, and strategic flexibility and financial performance are significant, which is a complete intermediary role. If the relationship between the two is still significant but weakened, then strategic flexibility plays a part in mediating roles. In step one, based on control variables, Model 3 tests the main effect of BDC on financial performance, and the result is verified, and Step two continues to test the influence of BDC on strategic flexibility, the intermediary variables. Model 7 and Model 8 show that quadratic term of BDC is significantly negatively correlated with the strategic flexibility (β = -0.112, $p < 0.05$), and the first power of BDC is positively correlated with the strategic flexibility (β = 0.659, $p < 0.001$), hypothesis 2 is verified. In Step three, strategic flexibility is put into the main effect relationship and Model 4 shows that the regression coefficient of BDC quadratic term on financial performance is significant (β = -0.148, $p < 0.05$), and the financial performance in model 6 is also significantly positively affected by strategic flexibility (β = 0.505, $p < 0.001$), indicating that strategic flexibility has the partial mediating effect, assuming data support 3.
To further demonstrate the mediating effect of strategic flexibility, the bootstrap method performed repeat sampling to expand the sample size to 5,000 with a 95% confidence interval. The specific result is shown in **Table 6**. The coefficient of strategic flexibility is 0.23, and the confidence interval did not include 0 (0.074, 0.387). Therefore, the mediating role of strategic flexibility between BDC and financial performance is established, and H3 is verified.

(3) Moderating effect testing: Establish a regulatory mediation model and test the regulatory effect of environmental dynamics according to the method recommended by Edwards and Lambert (2007). After controlling industry type, firm size, annual sales, and ownership, the interaction items of BDC and environmental dynamics are decentralised and then brought into the model to construct the first-power item and quadratic interaction item of BDC, as shown in **Table 7**, in Model 4, the quadratic interaction item of BDC and environmental dynamics is significantly positive (β = 0.228, $p < 0.05$), indicating that strategic flexibility plays a regulatory role in the "Converse-U" relationship between BDC and financial performance.

Simple slope analysis is continued to further explain the moderating effect of environmental dynamics (Aiken and West, 1991). The part whose environmental dynamics are less than its mean minus standard deviation is divided into the low correlation group (0–3.619). The mean plus standard

TABLE 6 | Bootstrap analysis of mediating effects.

Path	Effect value	Standard error	95% CI	
			Lower limit	Upper limit
BDC-SF-FP	0.230	0.079	0.074	0.387

TABLE 7 | Moderating effect analysis.

Variable		SF			
		Model 1	Model 2	Model 3	Model 4
Control variable	Industry type	0.040***	0.009	0.005	0.002
	Firm size	−0.026	−0.018	−0.025	−0.029
	Annual sales	0.116***	0.048	0.042	0.038
	Ownership	−0.024	−0.051	−0.049	−0.048
Argument	BDC^2		−0.560***	−0.486***	−0.399***
Adjusting variable	ED			0.292***	0.169*
Interactions	$BDC^2 \times ED$				0.228*
Regression index	R^2	0.092	0.325	0.384	0.395
	Adj-R^2	0.078	0.312	0.370	0.379
	F-value	6.785	25.753	27.751	24.834

*Significance level: ***means 0.1%, **means 1%, and *means 5%.*

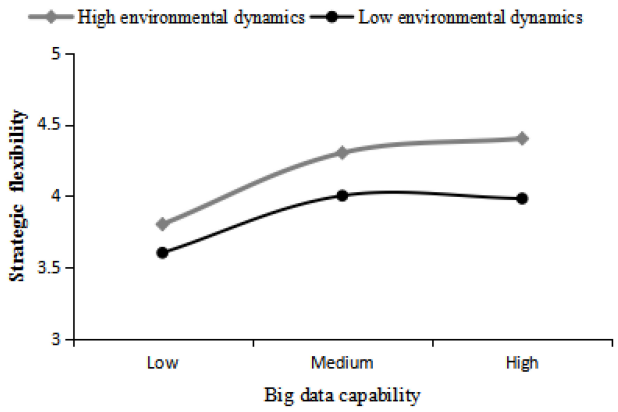

FIGURE 2 | Moderating effect of environmental dynamic.

deviation part is divided into a high correlation group (4.658–5). Results show that environmental dynamic positively moderates the "Converse-U" relationship between BDC and financial performance. As shown in **Figure 2**, the higher environmental dynamics is the weaker "Converse-U" impact of BDC on financial performance. In other words, the negative impact of excessive BDC on financial performance is reduced, and the critical point is at a higher level of BDC. It can be seen that the high-dynamic environment is more conducive for enterprises to exert the positive effect of BDC on financial performance to a greater extent, which verifies hypothesis 4.

CONCLUSION

Based on dynamic capability theory, this paper verifies the relationship between BDC and financial performance in the context of digital transformation in COVID-19 and the mediating effect of strategic flexibility and the regulating mechanism of environmental dynamics. Results show that BDC has a "Converse-U" effect on financial performance, further expanding the existing research conclusions on the relationship between BDC and financial performance. Previous studies have confirmed a positive linear relationship between BDC and financial performance (Barton and Court, 2012; Chen et al., 2015). This paper verifies the nonlinear relationship between BDC and financial performance based on a previous study. Further, it explains the key factors that drive the improvement of financial performance and the contextual factors that BDC plays a significant role. The results show that appropriate utilisation of data platforms and emerging technology would be conducive to completing the collection and integration of tangible and intangible resources from inside and outside, mining data value and getting insight into the relationship between the real market to better grasp the customer demand and potential business opportunities, and finally function in profitability increase, customer maintenance level improvement, and sales rate growth. That means strengthening the ability to integrate and utilise big data resources to improve performance has become a crucial part of business management in the environment of data explosion. Secondly, BDC has a "Converse-U" effect on strategic flexibility. Strategic flexibility is an important transmission mechanism of the impact of BDC on financial performance and plays an intermediation role in the "Converse-U" relationship between BDC and financial performance. Previous studies tend to focus on the direct effect of BDC on financial performance, ignoring the possible mechanism between BDC and financial performance. This paper verifies the role of strategic flexibility, which provides a theoretical basis for the positive effect of BDC on financial performance through the development of strategic flexibility in a dynamic environment. Therefore, enterprises should be equipped with flexible resources and capabilities to meet the needs of business activities and possess the capability to efficiently utilise their resources and seek new resources to consolidate and strengthen competitive advantages. Thirdly, environmental dynamics positively regulates the relationship between BDC and financial performance, causing the "Converse-U" relationship to be flat, weakening the negative impact of excessive construction of BDC on financial performance. Higher environmental dynamics mean increasing unpredictability, while big data technology in-depth analysis of massive data makes enterprises better cope with environmental challenges. Big data insight and prediction capability complete market trend tracking and make it possible for enterprises to launch products or services that satisfy market demands before competitors, thus consolidating market position and improving competitive advantages. Therefore, a high dynamic environment is more conducive to playing a positive role of BDC on financial performance.

The relevant conclusions of this study can provide some meaningful implications for enterprises in the COVID-19 era: First, in the context of COVID-19, big data and technology have demonstrated strong advantages in improving enterprise management and services. On the one hand, the rapid development of the online economy caused by COVID-19 has greatly enriched the data sources of enterprises, facilitated their access to comprehensive and accurate industry data, and optimised them to cope with risks and challenges. On the other hand, BDC enables enterprises to rapidly update products and services based on market changes, personalised marketing, consummate pricing systems, optimise manufacturing and service processes, strengthen dynamic capability, and eventually elevate environmental adaptability and adjustment capability of enterprises. Enterprises can encourage activities related to big data, such as data mining, integrated statistics, model prediction, and other activities to analyse internal and external data to find potential market opportunities. It is essential to construct BDC appropriately, such as digital transformation in all aspects of production and service. Amount of time and money will be invested in constructing an enterprise's excessive BDC, which will lead to less investment and attention on other aspects.

Meanwhile, the matching and coordination between BDC and capabilities required by the original business cannot be considered, resulting in a decline in the enterprise's financial performance. Over-emphasis on BDC building is more likely to fall into the paradox of "capability trap." Therefore, in

the construction and management of BDC, strengthening the matching degree with the original business and capabilities and then carrying out appropriate management and control to enhance financial performance is essential.

Next, enterprises should pay attention to the crucial role of strategic flexibility in the integrative development of big data. The sudden outbreak of COVID-19 has brought about rapid changes in the market environment, with many enterprises facing the dilemma of increased operational risks and resource constraints, making it difficult for the enterprise to complete operating activities based on the existing resources inhibiting the financial performance advance. Enterprise managers should construct an effective strategic flexibility formation mechanism and, moreover, promote organisational flexibility in human resources, corporate culture, and organisation structure by cultivating emotional core competence. Attention is needed to be paid to excavating the potential value of existing capacity and resources, rationally allocating existing resources, and absorbing new resources to strengthen strategic flexibility. In resource flexibility, on the one hand, the enterprise should weaken the degree of dependence on resources and actively look for alternative resources, such as diversification of upstream and downstream suppliers, talent introduction, and training.

On the other hand, enterprises need to increase the degree of resources transformation, cater to the current market demand, establish market development and product research team to clarify market dynamics, and demand status in real-time. In terms of capability flexibility, dynamic capability should be established to improve the comprehensive capability of enterprises in response to emergencies. In the context of COVID-19, factors affecting flexibility, such as good cash flow and financial status, can help enterprises improve their coping ability and weather rapid changes in the external environment.

In the context of big data, companies should rationally view environmental dynamics, fully realise that environmental fluctuations are both opportunities and challenges, and should adopt a variety of flexible ways to avoid the adverse effects of institutional support and market strategy lag on organisational operations and then promote the organisation performance improvement—the suddenness of COVID-19 tests whether enterprises can form resilience in adverse events. Firms can take the opportunity to upgrade their business models and promote the corporate transformation to form key competitive advantages. The practice has shown that environmental dynamics negatively correlate with corporate performance (Fuli and Shuhong, 2019), especially in high dynamic conditions. The unpredictability of the financial markets and environment urges enterprises to use the results of data analysis to gain insight into development trends, constantly adjust strategic goals and plans, and ensure the adaptability of the BDC cultivation process to environmental changes. In the context of COVID-19, the decline and delay in demand hit the survival and development of enterprises, especially small and medium-sized enterprises. As a result, accelerating digital transformation and propelling business model upgrade is the key to promoting business recovery. Big data technology should be utilised to realise accurate analysis and deep exploration of market trends and business opportunities.

Finally, it is important to note that the research sample is not limited to specific industries. Comparative research can be carried out for some specific industries to increase the persuasiveness of the research conclusions in the future. Secondly, this research is based on cross-sectional data. Without carrying out longitudinal dynamic evolution analysis on the relationship between variables, further research can be conducted to reveal the dynamic relationship among BDC, strategic flexibility, and financial performance through long-term tracking investigation. Thirdly, further enrich contextual variables of BDC's research, such as corporate culture and organisational learning, and further explore other mediating variables and regulating mechanisms. It is also possible to compare the impact of BDC on financial performance in China and other countries. These are the research directions that can be further explored in the future.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Nanjing University of Posts and Telecommunications. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LC: data curation and empirical analyses. LZ: writing the manuscript and mentoring. WZ: writing the manuscript and methodology. GL: writing the manuscript and visualisation. JZ: reviewing the manuscript and conceptualisation. YZ: reviewing the manuscript and validation. All authors contributed to the article and approved the submitted version.

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BRIEF RESEARCH REPORT
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The Effects of Passenger Risk Perception During the COVID-19 Pandemic on Airline Industry: Evidence From the United States Stock Market

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The COVID-19 pandemic has caused a dramatic reshaping of passenger risk perception for airline industry. The sharp increase in risk aversion by air passenger has caused a disastrous impact on the tourism service industry, particularly airline industry. Although the existing literature has provided a lot of studies on the impact of the pandemic on travel industry, there are very few studies discussing the impact of change in passenger risk perception on the stock market performance of airline industry. This study considers two types of airline companies, full-service and low-cost. In order to overcome the traditional problem of the Chow test, Quandt–Andrews test is used to identify structural change points during the pandemic in the stock prices of United States airline companies. The result shows that an industry-wide structural change in the stock market performance indeed is found to take place during the pandemic for United States airline companies. Meanwhile, no significant difference is found in the structural change date between the two types of airline companies. The selected airline companies are found to be clustered toward the end of 2020 (November and December) in their structural change dates. Although the strike of the COVID-19 pandemic on airline industry has proven to be widespread and profound, our investigation implies that air passengers have gradually adapted to the new normal of travel activities at some level and partly rebuild their sense of safety under the strict epidemic-control measures.

Keywords: risk perception, COVID-19, Quandt–Andrews test, risk aversion, airline industry

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INTRODUCTION

In 2020, the COVID-19 pandemic has spread widely throughout the United States. As of October 5, 2021, there have been more than 44 million confirmed cases in the United States, and the cumulative death toll has exceeded 720,000. There are more than 200 countries or regions around the world with confirmed COVID-19 cases As of October 5, 2021, the cumulative number of confirmed diagnoses worldwide has exceeded 236 million, and the cumulative death toll has exceeded 4.82 million, which will undoubtedly have a huge impact on the global economy. The COVID-19 pandemic has caused the stagnation of social and economic activities and caused panic and large fluctuations in the global financial market. In order to combat the epidemic, many countries have adopted

measures such as border-closing and travel restriction. Epidemic prevention measures include social distancing and travel minimization. The COVID-19 epidemic has also had a disastrous impact on the tourism service industry. The United Nations World Tourism Organization (UNWTO) report shows that the number of global international tourists in 2020 has declined by more than 1 billion, up to 74% of 2019 number. And global tourism revenue has decreased 1.3 trillion United States dollars, a decrease of 11 times that of the 2009 global financial crisis, with a direct loss of 100 million to 120 million jobs (UN-WTO, 2020).

During the epidemic, governments have demanded travel minimization. This has a devastating impact on the global airline industry: passenger traffic was 1.8 billion in 2020, a decrease of 60.2% from the 4.5 billion in 2019. Year 2020 witnessed the largest fall in air passenger traffic since 1950 (International Air Transport Association, 2020). One of the major drivers of this substantial decline in airline passenger travel is the risk perception of air passengers. This study aims to investigate the effect of the considerable change in passenger risk perception on airline industry by looking at stock market performance. Particularly, the research question to address is whether there exists an identifiable change in the stock market performance of airline industry. In this paper, sample United States airline companies were selected to represent different airline types. The Quandt–Andrews test was used to determine structural change points so as to better investigate the effect of passenger risk perception in the context of COVID-19. The rest of the paper is structured as follows. The Literature Review section examines the relevant existing literature. The Data and Methodology section discusses data selection and empirical model. The Empirical Results section lays out the results and the Conclusion section discusses policy implications.

LITERATURE REVIEW

The existing literature on the COVID-19 pandemic and airline industry is concentrated on the economic impact of the pandemic on airline industry. Maneenop and Kotcharin (2020) examined the short-term effect of COVID-19 outbreak on 52 listed airline companies' stock prices. Based on their results, airline stock return has significantly declined after three major COVID-19 announcements were made. Based on global air passenger traffic data, Lacus et al. (2020) studies the impact of the travel ban on airline industry. Their study found that the impact caused an average decline in global GDP by 0.02–0.12% in the first quarter of 2020. As for the COVID-19 related risk of air travel, Zhang et al. (2020) constructed a risk index based on daily dynamic international aviation data to measure the imported case risk on inbound international flights. They found that after China imposed restrictions on inbound flights, the imported case risk could be effectively controlled and the number of imported cases has fallen by about 50%.

In terms of business models, airline companies can be divided into two types, low-cost versus full-service. This distinction becomes a common practice in relevant empirical studies. Gong et al. (2006) suggests that it is better to distinguish between different types of airlines for empirical investigation. Low cost airlines are mainly characterized by online ticket booking, no free meals, standardized flight fleet, high aircraft utilization, and service outsourcing (Mason and Morrison, 2009; Teece, 2010; Diaconu, 2012; Pereira and Caetano, 2015; Dobruszkes and Wang, 2019). In terms of routes, due to strict regulations on long-distance transportation services, low-cost airlines mainly serve short- and medium-distance routes (Jiang, 2013; Albers et al., 2020). By contrast, the most distinctive feature of full service airlines is customer segmentation, the provision of a variety of different cabins (from first-class cabins, business class, to economy class). In addition, full-service airlines also have the following characteristics: in-flight meals, personalized services, large-scale network routes, extensive distribution channels, and complete supporting facilities (O'Connell, 2019).

Some scholars explore how different types of airline companies were affected by major travel crises. Ding et al. (2021) evaluate the connection between corporate characteristic and stock returns. They found that the decline in stock prices is more significant for firms with stronger financial conditions (more cash, less debts, and larger profits) and with less exposure to global supply chains. Carter and Simkins (2004) investigate the reaction of airline stock prices to 9/11 terrorist attack and found that there exists a variance in the impact on airline stock prices. Flouris and Walker (2005) also explore the effects of 9/11 terrorist attack on low-cost airline and full-service airline. The results found that the performance of Southwest Airlines, a typical low-cost airline, was much better than full-service airlines. Kökény et al. (2021) examine the impact of COVID-19 on the stock market performance of listed European airlines. In addition, the existing studies indicate that the impact of an external shock varies across different airline companies.

There has been abundant existing literature on the impact of epidemic on airline industry. However, there are few studies discussing the heterogeneous impact of public health events such as the COVID-19 epidemic on different types of airline industry. Therefore, this paper carefully distinguishes between different airline types in studying the impact of passenger risk perception driven by the COVID-19 epidemic on airlines. The Quandt–Andrews test is used to identify structural change points in the stock prices of United States airline industry. Then, based on the results from the empirical analysis of airline industry, a comparative analysis is conducted on the different types of airlines in the United States.

DATA AND METHODOLOGY

We use the time series data on stock price from Wind-Economic Database for this study. For the selection of sample period, it should be noted that the COVID-19 pandemic did not strike the United States economy at large scale until March, 2020. The number of confirmed cases before March stayed below 100. By contrast, the number of confirmed cases began to experience exponential growth in March 2020. We consider the period of February 28, 2020 to September 14, 2021, which contains a total of 564 trading days. Five airline companies (American Airlines,

Alaska Airlines, Delta Air Lines, United Airlines, and Hawaiian Airlines) were selected as sample full-service airlines. Meanwhile, Southwest Airlines, JetBlue Airways, Spirit Airlines, Allegiance Airlines, Ryanair were selected as sample low-cost airlines. Instead of closing stock quotations and opening stock prices, we use the average daily stock price for selected United States airline companies.

The Chow test (Chow, 1960) has been widely used for parameter stability testing in the existing literature. This method is very effective in testing structural change in economic

TABLE 1 | Quandt–Andrews test results.

Business model	Airline company	Structural change	Statistics		*p*-Value
Full-service	American Airlines	January 28, 2021	Maximum Wald *F*-statistic	1213.413	0.000
			Exp Wald *F*-statistic	601.2568	0.000
			Ave Wald *F*-statistic	437.8184	0.000
	Alaska Air	November 23, 2020	Maximum Wald *F*-statistic	1247.887	0.000
			Exp Wald *F*-statistic	618.749	0.000
			Ave Wald *F*-statistic	529.046	0.000
	Delta	November 16, 2020	Maximum Wald *F*-statistic	872.7903	0.000
			Exp Wald *F*-statistic	431.4397	0.000
			Ave Wald *F*-statistic	342.5232	0.000
	United Airlines	November 24, 2020	Maximum Wald *F*-statistic	577.2857	0.000
			Exp Wald *F*-statistic	283.4525	0.000
			Ave Wald *F*-statistic	275.0632	0.000
	Hawaiian Airlines	November 09, 2020	Maximum Wald *F*-statistic	877.48	0.000
			Exp Wald *F*-statistic	433.2051	0.000
			Ave Wald *F*-statistic	361.0949	0.000
Low-cost	Southwest Airlines	November 16, 2020	Maximum Wald *F*-statistic	950.1833	0.000
			Exp Wald *F*-statistic	469.8046	0.000
			Ave Wald *F*-statistic	455.259	0.000
	JetBlue	November 09, 2020	Maximum Wald *F*-statistic	758.9487	0.000
			Exp Wald *F*-statistic	373.9351	0.000
			Ave Wald *F*-statistic	357.6673	0.000
	Spirit Airlines	December 03, 2020	Maximum Wald *F*-statistic	912.8687	0.000
			Exp Wald *F*-statistic	451.1336	0.000
			Ave Wald *F*-statistic	379.2932	0.000
	Allegiant Air	December 03, 2020	Maximum Wald *F*-statistic	1278.903	0.000
			Exp Wald *F*-statistic	634.2814	0.000
			Ave Wald *F*-statistic	525.5729	0.000
	Ryanair	November 09, 2020	Maximum Wald *F*-statistic	1853.522	0.000
			Exp Wald *F*-statistic	921.2082	0.000
			Ave Wald *F*-statistic	637.6137	0.000

TABLE 2 | Descriptive statistics of stock prices before and after structural change unit: USD.

	Variable	Before the structural change point			After the structural change point			Percentage change
		Obs	Mean	SD	Obs	Mean	SD	
Full-service	American Airlines	219	13.35	2.33	150	21.38	1.92	60.1
	Alaska Air	175	36.42	5.77	194	60.36	7.09	65.7
	Delta	170	29.21	5.51	199	43.29	3.57	48.2
	United Airlines	176	34.41	7.01	193	50.11	5.51	45.6
	Hawaiian Airlines	165	13.63	2.21	204	22.62	3.36	66.0
Low-cost	Southwest Airlines	170	35.73	4.78	199	53.39	6.02	49.4
	JetBlue	165	10.96	1.75	204	16.97	2.32	54.8
	Spirit Airlines	182	16.63	3.79	187	30.76	5.08	84.9
	Allegiant Air	182	114.91	25.63	187	208.92	26.63	81.8
	Ryanair	165	71.36	11.38	204	109.02	4.64	52.8

indicators at a given time. However, the Chow test has limitations as this test requires that the tested model does not miss important variables and there is no systematic error in the model setting. It also assumes that the explanatory variables are not correlated with the random disturbance for each sub-interval. Given the limitations of the Chow test, Quandt, and Andrews proposed a test method for unknown change points. The statistics of Quandt–Andrews test include three types: (1) the largest statistic, obtained from the Chow test; (2) Ave statistic, the simple arithmetic mean of *F*-statistic values obtained from the Chow test; and (3) Exp statistic. The result of the test output includes these three statistic *F*-statistic and LR statistic. From each single Chow test, two constrained statistics can be obtained: likelihood ratio *F*-statistic and Wald *F*-statistics. The likelihood ratio *F*-statistic is a statistic based on the comparison of the residual sum of squares between the constrained and the unconstrained models. And the Wald *F*-statistic is calculated according to the standard Wald test. In an ordinary linear model, these two statistics turn out to be equal to each other. A single Chow test for split point can be summarized into three different statistics: the maximum statistics, the Exp statistic, and the Ave statistic (Andrews, 1993; UN-WTO, 2020).

The maximum statistic is the statistic obtained by taking the maximum value of a single statistic obtained in the test:

$$\max F = \max_{\tau_1 \leq \tau \leq \tau_2} F(\tau) \tag{1}$$

The Exp statistics is obtained as follows:

$$\exp F = \ln\left(\frac{1}{k}\sum_{\tau=\tau_1}^{\tau_2} \exp\left(\frac{1}{2}F(\tau)\right)\right) \tag{2}$$

The Ave statistic is the simple average of the individual statistics obtained:

$$AveF = \frac{1}{k}\sum_{\tau=\tau_1}^{\tau_2} F(\tau) \tag{3}$$

It should be noted that the distribution is non-standard for the above three statistics. Andrews (1993) derived the true distribution and then Hansen (1996) gives asymptotical *p*-value for the three statistics.

EMPIRICAL RESULTS

The Quandt–Andrews test is conducted on the above mentioned stock price time series data to test the parameter stability and to identify structural change. Then, the above three statistics are calculated and the asymptotic *p*-value is obtained for each calculated statistic.

Table 1 shows the results of the Quandt–Andrews test on the selected full-service airlines and low-cost airlines from the United States airline industry. Since the likelihood ratio *F*-statistic and Wald *F*-statistic are the same in an ordinary linear model, only the Wald *F*-statistic is shown in **Table 1**. The three major statistics all accept the hypothesis that there exist structural change points in the time series data at a significance level of 1%. As shown in **Table 1**, the distribution of structural change dates is relatively concentrated. The structural change for all representative companies with the exception of American Airlines is show to take place in the last 2 months of 2020 (November 2020 through December 2020). Meanwhile, no significant difference is found in structural change dates between low-cost airlines and full-service airlines. This result shows that there is no disparity in the pandemic impact across different airline types.

According to the structural change dates shown in **Table 1**, a comparative analysis was conducted on the descriptive statistics of the stock prices. The results are shown in **Table 2**. We find that pre-structural-change mean stock prices are shown to be higher than the post ones for all airline companies, which reflects a noticeable drop in passenger risk perception. Two low-cost carriers, Spirit Airlines and Allegiant Air, saw the biggest gains of more than 80%. Generally, the percentage change in the mean stock price is greater for low-cost airlines than for full-service airlines. Ryanair shows a significant decrease from 11.38 to 4.64 in price vitality indicating that its stock price became more stable after the structural change.

The outbreak of the COVID-19 early 2020 had exerted a disastrous impact on the United States airline industry regardless the airline type. This impact was seen in the substantial fall in airline stocks. However, the negative impact of the COVID-19 outbreak gradually diminished as air passenger risk perception reduced substantially. There are mainly two drivers for this risk perception reduction. First, to control in-flight transmission, United States airline industry has taken various preventive measures including mask use, temperature screening, and boarding requirement of negative testing results. Secondly, as air passengers have adapted to the new travel conditions, air travel demand, which was depressed during the outbreak of COVID-19 outbreak, experienced a moderate level of recovery.

CONCLUSION

This study analyzes the high-frequency daily stock market data to investigate the impact of a change in passenger risk perception driven by the COVID-19 epidemic on airline industry. We consider the heterogeneous impact of passenger risk perception on different airline types by examining the average daily stock price of the United States airline companies selected for full-service airlines and for low-cost airlines.

The result shows that there indeed exists an industry-wide structural change in stock market performance taking place during the pandemic for United States airline companies and the selected United States airline companies are shown to be clustered toward the end of 2020, particularly November and December, in stock price. Meanwhile, no significant difference is found in the structural change date between the two types of airline companies. We find that pre-structural-change mean stock prices are shown to be higher than the post ones for all airline companies.

Although global public health emergency can exert devastating impact on airline industry air, our results imply that passengers adapt themselves gradually to the new normal of travel activities amid potential lockdown and flight cancellation. Meanwhile, air passengers might respond to epidemic-control measures positively and update their perception of travel risk continuously. This behavior pattern is reflected in the structural change of airline stock prices that is found to take place toward the end of 2020. In addition, this implication of steady reduction in passenger risk perception seems to be consistent with some findings in the existing literature (Zhang et al., 2020).

Regarding policy implications, our results imply that the airline industry regulators should give more importance to the effect of COVID-19 prevention measures. Although the chance of in-flight transmission turns out to be very low, strict preventive measures including mask use, distance seating, temperature screening, and pre-boarding testing all help air passengers rebuild their sense of safety and reduce their risk perception. In the face of major public health events such as the COVID-19 epidemic, airline industry regulators should use big data in monitoring the trend and formulating policy responses in a timely manner. Meanwhile, quarantine of travelers may delay transmission or re-transmission of the virus, but it substantially increases the cost of long-haul travel particularly. By contrast, free cancellation, flexible bookings, and travel warning updates might help travelers handle COVID-19 related uncertainties. For future study, the question of how the measures that increase air travel flexibility affect air passenger risk perception might be worth investigation.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

ZL: conceptualization, methodology, formal analysis, writing–revision, and project management. LZ: methodology, data processing, and writing–original draft preparation. ZHL: conceptualization and funding acquisition. XL: methodology, writing–original draft preparation, and funding acquisition. YZ: methodology, data processing, and writing–revision draft preparation. All authors contributed to the article and approved the submitted version.

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Difference and Cluster Analysis on the Carbon Dioxide Emissions in China During COVID-19 Lockdown via a Complex Network Model

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The continuous increase of carbon emissions is a serious challenge all over the world, and many countries are striving to solve this problem. Since 2020, a widespread lockdown in the country to prevent the spread of COVID-19 escalated, severely restricting the movement of people and unnecessary economic activities, which unexpectedly reduced carbon emissions. This paper aims to analyze the carbon emissions data of 30 provinces in the 2020 and provide references for reducing emissions with epidemic lockdown measures. Based on the method of time series visualization, we transform the time series data into complex networks to find out the hidden information in these data. We found that the lockdown would bring about a short-term decrease in carbon emissions, and most provinces have a short time point of impact, which is closely related to the level of economic development and industrial structure. The current results provide some insights into the evolution of carbon emissions under COVID-19 blockade measures and valuable insights into energy conservation and response to the energy crisis in the post-epidemic era.

Keywords: time series, visibility graph, complex network, carbon dioxide emissions, K-means

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1. INTRODUCTION

Since the end of 2019, the outbreak of COVID-19 has had a major impact on the health and property of people all over the world. The world is almost in a state of "general lockdown" state as many governments have taken "shock" measures to prevent the outbreak by shutting down work and schools, closing borders, restricting travel and social isolation (Badesa et al., 2021). Despite the enormous losses caused by the lockdown, it is extremely important in controlling the epidemic, reducing carbon dioxide emissions, and prohibiting damage to people's health (Cicala et al., 2021). Relevant studies revealed that the lockdown during the COVID-19 resulted in significant reductions in stated emissions of nitrogen dioxide NO_2 and carbon dioxide CO_2 due to reduced transport activities (Celik and Gul, 2021), demand for electricity and the cessation of industrial activity, massive reductions in human activity, and significant reductions in fossil energy consumption (Usman et al., 2021). In China, for example, annual carbon dioxide emissions in 2020 was 2% lower than those in 2019, while this is the first decline since 1997 (Liu et al., 2020b). This situation calls for humanity's attention to the importance of protecting the ecological environment

and realizing the balanced development of economy and ecology (Hanna et al., 2020). Under this background, studies on the transition to a low-carbon economy are increasingly prominent (Ionescu, 2021b).

The low carbon economy is important for environmental performance, sustainable energy and promoting green financial behavior (Ionescu, 2020a), carbon pricing and pollution taxes continue to prove to be cost-effective economic instruments to curb greenhouse gas emissions (Ionescu, 2019, 2020b). Pflugmann and De Blasio (2020)'s research expands the scope of sustainable energy research through the new energy perspective of renewable hydrogen (Pflugmann and De Blasio, 2020). Ionescu (2021) confirmed the development and evolution of green finance in the COVID-19 pandemic for low-carbon energy, sustainable economic development and climate change mitigation by the data from NGFS and the United Nations (Ionescu, 2021a). In this study, we focus on investigating carbon emissions in China in 2020, which is under the global prevalence of COVID-19, because China is one of the major global emitters of greenhouse gases and the first country to take control measures against the COVID-19 (Liu et al., 2021c). Moreover, the COVID-19 had a significant impact on greenhouse gas emissions and the reduction of atmospheric pollutants in China (Filonchyk et al., 2020; Liu et al., 2020b). Zheng, et al. (2020) confirmed that China's CO2 emissions reduced by 11.5% from January to April 2020 compared to the amount during the same period in 2019 (Zheng et al., 2020). Exploring the impact of COVID-19 on China's carbon emissions is of great significance for promoting a low-carbon economy globally (Liu et al., 2020b).

However, there is a lack of real-time, quantitative studies on carbon emissions under COVID-19 combined with lockdown policies (Sreekanth et al., 2021; Zhou et al., 2021). In existing studies on COVID-19 and carbon emissions, carbon emission data are often collected monthly or annually, making the time lag. The complex network is a method to analyze the characteristics of relevant data from a temporal perspective and present them through graphs, animations, etc. (Lacasa et al., 2008). This method allows for a dynamic presentation of carbon emissions over time and deeply reveal the information behind the data (Chimmula and Zhang, 2020). For example, Wang, et al. (2021) used complex network theory to construct a network of carbon emission flows in key sectors in China across industries (Wang et al., 2021b). Similarly, to investigate the impact of industry-driven effects on carbon emissions, Zheng et al. (2021) combined multi-regional input-output theory with complex network theory to construct a network of industry-driven effects, the study showed that the different effects of industry-driven effects had a positive impact on carbon emissions (Zheng et al., 2021). However, previous studies have generally assumed regions to be homogeneous and little attention has been paid to differences in economic development when analyzing the greenhouse gas emissions. While carbon emissions are closely related to economic development level, regional transport and industry conditions, there is a lack of studies on regional heterogeneity. Therefore, there is an urgent need for real-time, high spatial emission datasets to quantify the impact of COVID-19 on carbon emissions across China.

The contributions of this paper are as follows: First, in terms of research methodology, the complex network method compensates for the data shortcomings of previous studies on lagging carbon emissions and extends the application of complex network analysis methods. Secondly, in practical application, the paper takes China, where the lockdown measures are stringent and carbon emissions have a large impact, and combines the dynamic change process of carbon emissions during the COVID-19 pandemic with the lockdown policies to provide scientific suggestions for the development of a low carbon economy in the post-epidemic era.

2. METHODOLOGY AND DATA

2.1. Visibility Graph

Network topology can be used to indicate the current status and behavior of system which may not be shown in the time series explicitly (Fan et al., 2019). In Lacasa et al. (2008) found a new algorithm to map time series into complex networks, which is a key problem in the research on time series, namely, visibility graph (*VG*). VG has also been proved to have two particularly eminent advantages: its topology inherits the characteristics of the time series involved and it shows **Supplementary Material** through degree distribution. Moreover, this novel relation between the time series and complex networks can provide a great many possibilities for the study of complex signals (Hu et al., 2020).

The algorithm of the network building method follows the principle: each node in the network corresponds to each time point in the discrete time-series data. Connect the two points in these nodes that meet the prescribed visibility rules in advance, which forms the edge of the network. The basic idea of the algorithm is shown in **Figure 1**. In the upper part of the graph, 18 straight squares are used to represent the first 20 data points in a periodic time series (**Figure 1A**). The height of the straight squares in the subgraph (**Figure 1A**) represents the data value of each time point. If the top of the two straight squares is visible to each other, the corresponding two points are connected in the network in the subgraph (**Figure 1B**). In graph (**Figure 1B**), each real point corresponds to the data point in the time series one by one. Specifically, each node can not be connected to itself, and each visible line can not pass through any straight bars.

If there are any two points of the carbon emission (t_a, x_a), and (t_b, x_b), the every points (t_c, x_c) between these two points, safeties the Equation (1), there will be an edge to link these two points,

$$x_b < x_a + (x_c - x_a)\frac{t_b - t_a}{t_c - t_a}. \quad (1)$$

2.2. Complex Network

The study of complex networks is permeating many different fields from mathematical and scientific disciplines to life and engineering disciplines, and the scientific understanding of the quantitative and qualitative characteristics of complex networks has become an extremely important and challenging topic. The advantage is that the structure of complex systems and the relationship between structure and function can be explored

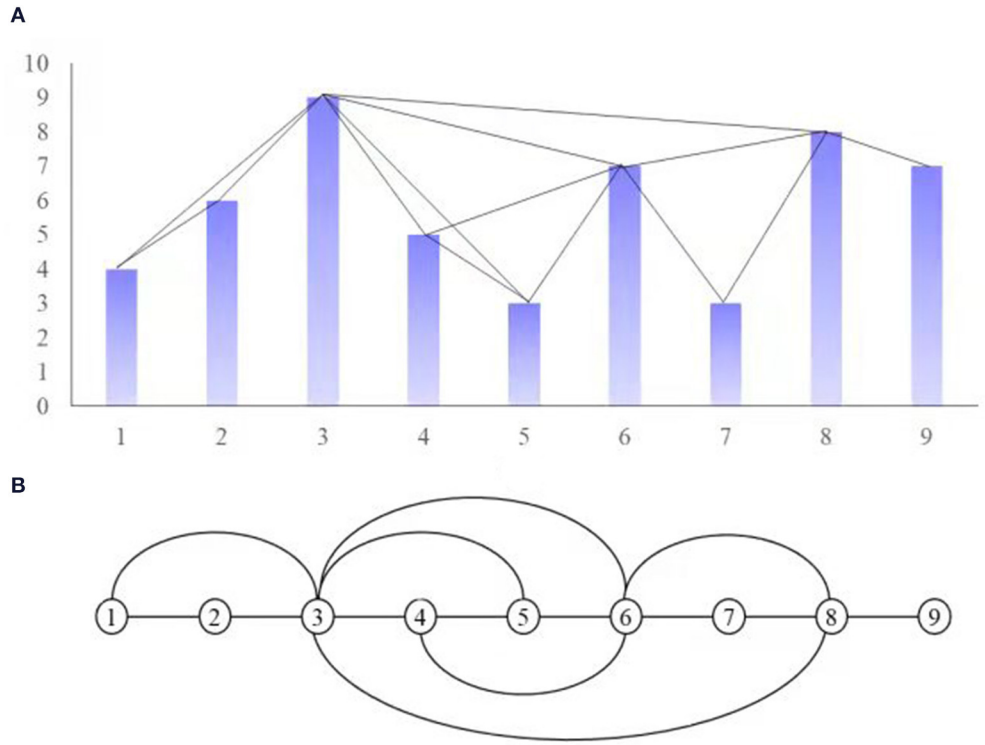

FIGURE 1 | Visiblity graph.

(Qiao et al., 2021). Network is a graph composed of nodes and edges. Its mathematical expression is $G = (N, V)$, where N is the aggregate of nodes and V is the set of edges. Complex network is a useful tool to analyze social problems, management science, computer, statistics and other problems. In this study, by transforming the time series into a network, we analyze the time series data through the statistical characteristics of the complex network, and mine more useful information in the time series, so that we can get more accurate analysis results. The statistical characteristics of complex networks are as follows:

2.2.1. Degree

In the complex network, d_i endnotes degree of the node i, which is the the number of the edges connected to the node i, and the average degree $< K >$ is the the average value of all the nodes' degree,

$$< k >= \frac{1}{N}\sum_{i=1}^{N} d_i, \tag{2}$$

where N is the number of the nodes in this network.

The degree distribution $p(k)$ is the frequencies of nodes with the $d_i = k$ in the complex network.

2.2.2. Average Path Length and Diameter

In the network science, the network characteristics can be used to describe by the distance between any two nodes, e.g., average path length and diameter. It's easy to know that the short path of the node i and node j is d_{ij}, and the average path length is the average short path L of all the short path between any two nodes, as given blow:

$$L = \frac{1}{N(N-1)}\sum_{1\le i<j\le N} d_{ij}, \tag{3}$$

and the diameter is the longest path in the all short path.

2.2.3. Clustering Coefficient

Cluster coefficient is a index to describe the aggregation degree of the each nodes in the network, and the average cluster coefficient endnote the the aggregation degree of the network. The definition of the cluster coefficient:

$$C_i = \frac{E_i}{C_{k_i}^2}, \tag{4}$$

where k_i is the number of neighbors of the node i, E_i is the number of actually existing edges, $C_{k_i}^2$ is the number of theoretically existing edges. And average cluster coefficient is:

$$C = \frac{1}{N}\sum_{i}^{N} C_i, \tag{5}$$

where C_i is the cluster coefficient of node i, N is the number of nodes.

2.3. K-means

A clustering algorithm is a method for automatically dividing a set of unlabeled data into multiple classes, which is an unsupervised learning method (Banerjee et al., 2005), aiming to categorize similar data into certain clusters (Tang et al., 2018). K-means clustering is the clustering method of assignments of data points based on similarity, and it's been proven to be more effective to optimize results (Yan et al., 2020). By manually setting the parameter K, n objects can be divided into k categories, which makes the similarity within the same category the highest, while the similarity between categories the lowest.

Based on a given set of N objects, the K-means algorithm will build k methods partition clustering methods, and each partition clustering is a cluster. The data is divided into n clusters, each cluster has at least one data object, and each data object must belong to and can only belong to one cluster. At the same time, the similarity of data objects in the same cluster is high, and the similarity of data objects in different clusters is low. The clustering similarity is calculated using the average value of objects in each cluster.

The processing flow of the K-means algorithm is as follows. First, it randomly selects k data objects, each data object represents a cluster center, namely, select k initial centers. Second, for each remaining object, it assigns an object to the most similar cluster according to the similarity (distance) with each cluster center. Then, it recalculates the average value of all objects in each cluster as the new cluster center. This process is repeated until the criterion function converges, as the cluster center does not change significantly. The mean square error is usually used as the criterion function to minimize the sum of the squares of the distances from each point to the nearest cluster center.

The technical route of this paper is illustrated in **Figure 2**. Firstly, in order to explore the nodes and linkage system of carbon emissions during the COVID-19 epidemic, time series analysis and visualization of carbon emissions are made. Secondly, a complex network of indicators is constructed to further explore the power-law distribution of nodes. Following this, a K-means analysis is conducted to incorporate regional heterogeneity and to form the final clusters.

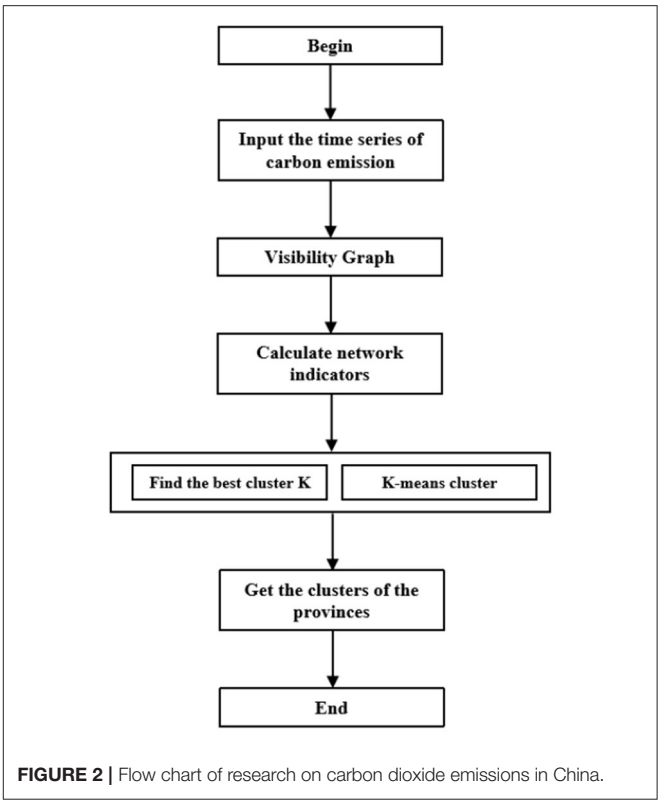

FIGURE 2 | Flow chart of research on carbon dioxide emissions in China.

2.4. Data Source

We collected daily data of daily confirmed COVID-19 cases of 30 provinces in China during 2020 from Git Hub. The macro indicators such as per capita GDP, secondary industry growth index and passenger volume of each province in 2020 were obtained from the National Bureau of Statistics and local statistical yearbooks. In addition, China's carbon emissions data of 30 provinces in 2020 are from the website (https://www.carbonmonitor.org.cn/) and reference (Liu et al., 2020a).

3. RESULT

3.1. Descriptive Analysis

We analyzed the total carbon emissions of 30 provinces in 2020. **Table 1** shows the statistical characteristics and changing trend of the total emissions of each province. We can see that the provinces with high carbon emissions are Shandong, Guangdong and Jiangsu. **Figure 3** shows the growth rate trend of carbon emissions by sector in 2020. Statistically, we can find that COVID-19 has brought about a short-term decrease in carbon emissions, especially during the period of national lockdown from January to March 2020, followed by a gradual increase in industrial, energy and residential carbon emissions. The impact on the transport sector is huge, because not only are carbon emissions from the lockdown down, but all transport emissions were in negative growth until September. The international aviation emissions remained in negative growth, due to the global COVID-19 pandemic, which greatly reduced international air transport.

In the case of confirmed COVID-19 in China, the country is the first to fight the outbreak compared to other countries in the epidemic area. Existing studies usually divide the time period into seed period from 2020.1.1 to 2020.1.23, and lockdown measure management from 2020.1.24 to 2020.3.8 (Liu et al., 2021a). At the time of the Wuhan outbreak in January, there was no clear evidence of direct differentiation from other known influenza viruses. During the first days of the transmission, local authorities were busy controlling the spread of the disease and ensuring that all COVID-19 patients were well cared for. Meanwhile, infected areas such as the Wuhan seafood market were immediately closed and thoroughly disinfected. With Hubei province declaring a level II public health emergency response, Wuhan closed its access on January 23, then Hubei and other provinces across the country began to collective fight the virus. As a result of this series of "closures and social distancing"

TABLE 1 | Statistical indicators of carbon dioxide emissions of 30 provinces.

	AVG	SE	Med	SD	Var	Kur	Ske	Min	Max	Sum[a]
Beijing	0.16	0.00	0.16	0.04	0.002	–0.45	–0.06	0.07	0.26	60.25
Tianjin	0.22	0.00	0.22	0.06	0.004	1.16	–1.12	0.06	0.32	79.37
Hebei	1.31	0.01	1.38	0.27	0.074	–0.86	–0.63	0.75	1.83	478.76
Shanxi	0.97	0.01	1.02	0.23	0.053	0.18	–1.03	0.39	1.39	353.62
Inner Mongolia	1.26	0.02	1.34	0.35	0.123	1.23	–1.25	0.31	1.76	459.81
Liaoning	0.65	0.01	0.69	0.16	0.026	–1.06	–0.46	0.34	0.95	239.45
Jilin	0.30	0.00	0.30	0.08	0.006	–1.15	–0.05	0.16	0.43	108.90
Heilongjiang	0.35	0.00	0.34	0.09	0.008	–1.12	–0.09	0.19	0.51	126.76
Shanghai	0.24	0.00	0.23	0.07	0.006	0.56	–0.39	0.06	0.37	86.30
Jiangsu	1.88	0.02	1.95	0.44	0.193	–0.43	–0.47	0.91	2.64	687.49
Zhejiang	1.33	0.02	1.43	0.32	0.101	–0.63	–0.73	0.65	1.91	485.67
Anhui	1.33	0.01	1.35	0.26	0.070	–0.44	–0.21	0.77	1.87	488.10
Fujian	0.88	0.01	0.88	0.18	0.031	–0.98	–0.33	0.51	1.19	323.08
Jiangxi	0.79	0.01	0.79	0.16	0.025	–0.97	–0.10	0.48	1.14	287.75
Shandong	2.06	0.02	2.19	0.42	0.176	0.10	–0.98	1.03	2.91	753.34
Henan	1.25	0.01	1.33	0.23	0.053	–0.29	–0.98	0.72	1.60	458.76
Hubei	0.82	0.01	0.82	0.25	0.060	–0.41	–0.02	0.32	1.32	301.83
Hunan	0.81	0.01	0.81	0.16	0.025	–0.24	0.38	0.51	1.16	296.21
Guangdong	1.82	0.02	1.93	0.40	0.164	–0.74	–0.51	0.97	2.55	666.28
Guangxi	0.90	0.01	0.89	0.15	0.024	–0.40	0.25	0.58	1.24	328.07
Hainan	0.15	0.00	0.15	0.03	0.001	–1.01	–0.32	0.09	0.19	53.62
Chongqing	0.48	0.00	0.49	0.09	0.008	–0.55	0.27	0.28	0.68	176.79
Sichuan	0.95	0.01	0.94	0.15	0.023	–0.60	0.33	0.57	1.27	347.17
Guizhou	0.87	0.01	0.90	0.20	0.041	–0.68	–0.12	0.46	1.32	319.63
Yunnan	0.80	0.01	0.83	0.14	0.019	–0.72	–0.11	0.47	1.08	293.52
Shaanxi	0.83	0.01	0.88	0.15	0.023	0.34	–1.12	0.43	1.16	304.00
Gansu	0.44	0.00	0.47	0.09	0.007	–0.19	–0.85	0.24	0.63	162.45
Qinghai	0.09	0.00	0.10	0.02	0.000	0.49	–1.08	0.04	0.13	33.22
Ningxia	0.45	0.01	0.48	0.11	0.013	1.41	–1.44	0.13	0.63	162.99
Xinjiang	0.93	0.01	1.00	0.23	0.052	1.46	–1.41	0.29	1.30	340.60

[a]*AVG, Average value; SE, Standard error; Med, Median; SD, Standard deviation; Var, Variance; Kur, Kurtosis;, Ske, Skewness; Min, Minimum; Max, Maximum.*

policies, the number of confirmed cases in China has dropped by 71 percent (Thu et al., 2020). After March, China has been cautiously and gradually reopening its economy, and there have been few large-scale infections as the country has stepped up measures to ensure national security. The epidemic has been managed with various but effective actions by different provinces, all of which have succeeded in adopting enthusiastic and cooperative people and appropriate government measures (Balsalobre-Lorente et al., 2020). **Table 2** shows China's lockdown measures during this period.

3.2. Carbon Emissions and Lockdown

Figure 4 shows the network characteristics of 30 provinces analyzed through the visibility graph, where the darker the color, the greater the value of the topology measures of this network. From the results, we conclude that: (1) The network topology can indicate and inherit the properties of the current network. (2) Networks implemented in the corresponding time series can reveal the true nature of the time series in question with reference to specified indicators. (3) the link between complex networks and time series provides researchers with a general method to examine the process of complex signals with several different possibilities.

Figure 5 shows the degree distribution of visibility graphs of 30 provinces in China, from the sub-figures, it's easy to find that the degree distribution of 30 provinces are long-term correlation and the power law distribution, which means that the VG of these 30 provinces are the scale-free network, and the distribution fitting parameters and the goodness of fit R2 of 30 provinces are shown in **Table 3**. According to the visual rules and the degree distribution we know that only few with large degree, which means that few time have the large influence. The majority node with low degree, which is that the influence range of the most time nodes is short. This also reflects to some extent the timeliness of the epidemic prevention and control policy.

In the short term, from January to March 2020, with the emergence of patients with unexplained pneumonia in Wuhan, the country successively from the beginning of the implementation of lockdown measures. At this time, the overall value of carbon emissions in the country is low and mostly the

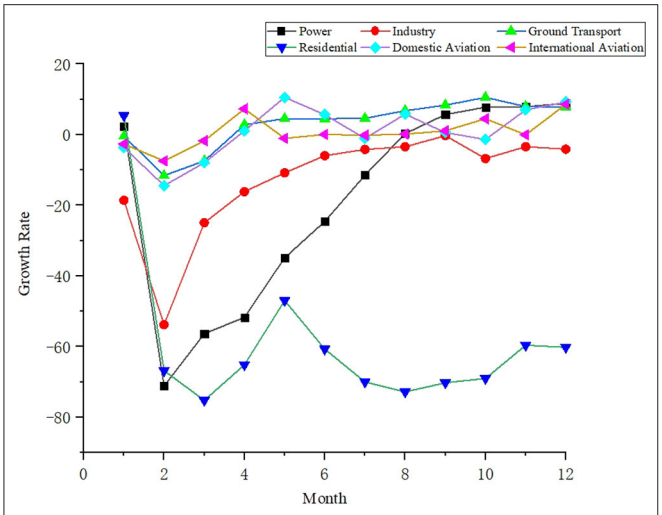

FIGURE 3 | Trend line for the growth rate of carbon emissions of 30 provinces in 2020.

TABLE 2 | China's lockdown measures.

Lockdown	Area	Requirement	Means
City	Cities with multiple confirmed cases, such as Hubei	Restrictions on the mobility of people, suspend all work, business and schools	Suspension and closure of all modes of transport, restrictions on private cars, community closures
Road	National and provincial highways, entrances and exits, and some roads in the city	Temporary closure of highway department exits and vehicles were prohibited	Warning signs, cordons, roadblocks, etc.
Community	There were no or few confirmed cases, such as Hebei.	Closed management; no foreign vehicles; no foreigners; restricted access to residents	Only one passageway is reserved for residents with access cards and limits the number of outside times
Door	Returning residents of infected areas or those close with confirmed cases	Forced isolation for more than 14 days and strictly forbidden to go outside	Real-time reporting of body temperature and other health conditions through in-home testing

From: China's provinces, cities, and community announcement.

impact of the nodes is short. The Spring Festival is the most festive time of the year in China, during which people return to their hometowns in a mass migration of people (Jia et al., 2021). This mass movement forms the topology of a population movement network that connects most major cities, initiating the chain of transmission of COVID-19 in China (Govindan et al., 2020; Khan et al., 2020). However, the closure measures in most provinces make the node degree low and the temporal impact on carbon emissions short in extent.

In the long term, 18 months of carbon emission data for each sector in China from 2020.01 to 2021.06 are selected, as shown in **Figure 6**. We can see that the impact of urban lockdowns on air pollution is short term, with rising emissions from energy, industry and land transport as closure policies continue to be liberalized across the region. It is worth noting that at month 14 (February 2020), greenhouse gas emissions from all sectors fall further to the level of the beginning of the year, due to the Spring Festival. The national promotion of "New Year in Place" has led to a reduction in transport and lower energy demand.

In addition, energy emissions increased significantly between Nov. 2020 and Mar. 2021, which can be explained by China's heating system. The impact of the blockade will be greater in the colder northern cities, which rely more on inefficient and inflexible coal-based winter central heating systems for residential and workplace buildings (Liu et al., 2021b). During the blockade, people are no longer required to work or go to school, so the heating of office/school buildings can be turned off completely, thereby reducing coal consumption. In contrast, the use of residential winter heating will not change much, as residential buildings must maintain their winter heating systems throughout the winter (Cui et al., 2021). Therefore, carbon emissions during this period are closely related to human behavior.

3.3. Carbon Emissions and Regional Heterogeneity

To further analyze carbon emissions from COVID-19 lockdown based on regional characteristics, we selected GDP per capita, total carbon emissions, passenger traffic, value added of the secondary industry in each province in 2020, and the number of confirmed cases from 2020.1.23 to 2020.3.8 (the period of COVID-19 lockdown in China) to construct a complex network visibility graph and further perform cluster analysis.

Specifically, the edges, mean path lengths, mean clustering coefficients and mean degrees of confirmed cases during the epidemic closure period were generated using the same method, and the best four clusters were selected by combining data on GDP per capita, total carbon emissions, passenger traffic and value added of secondary industries, as shown in **Table 4**. These two places have a high level of economic development, and at the same time focus on the development of tertiary industries rather than secondary industries, and therefore have relatively low carbon emissions. The provinces in Cluster 2 have a higher level of economic development and have higher carbon emissions, not only in terms of the development of the secondary sector but also in terms of the amount of passenger traffic. The provinces in the third cluster have a lower level of economic development compared to most of the first two clusters, and have a well-developed policy of epidemic lockdown, especially represented by the prevention and control in rural areas of Henan province. In addition, the geographical distribution is block-shaped. The provinces in the last cluster have an overall low level of carbon emissions, a better situation in the primary sector than

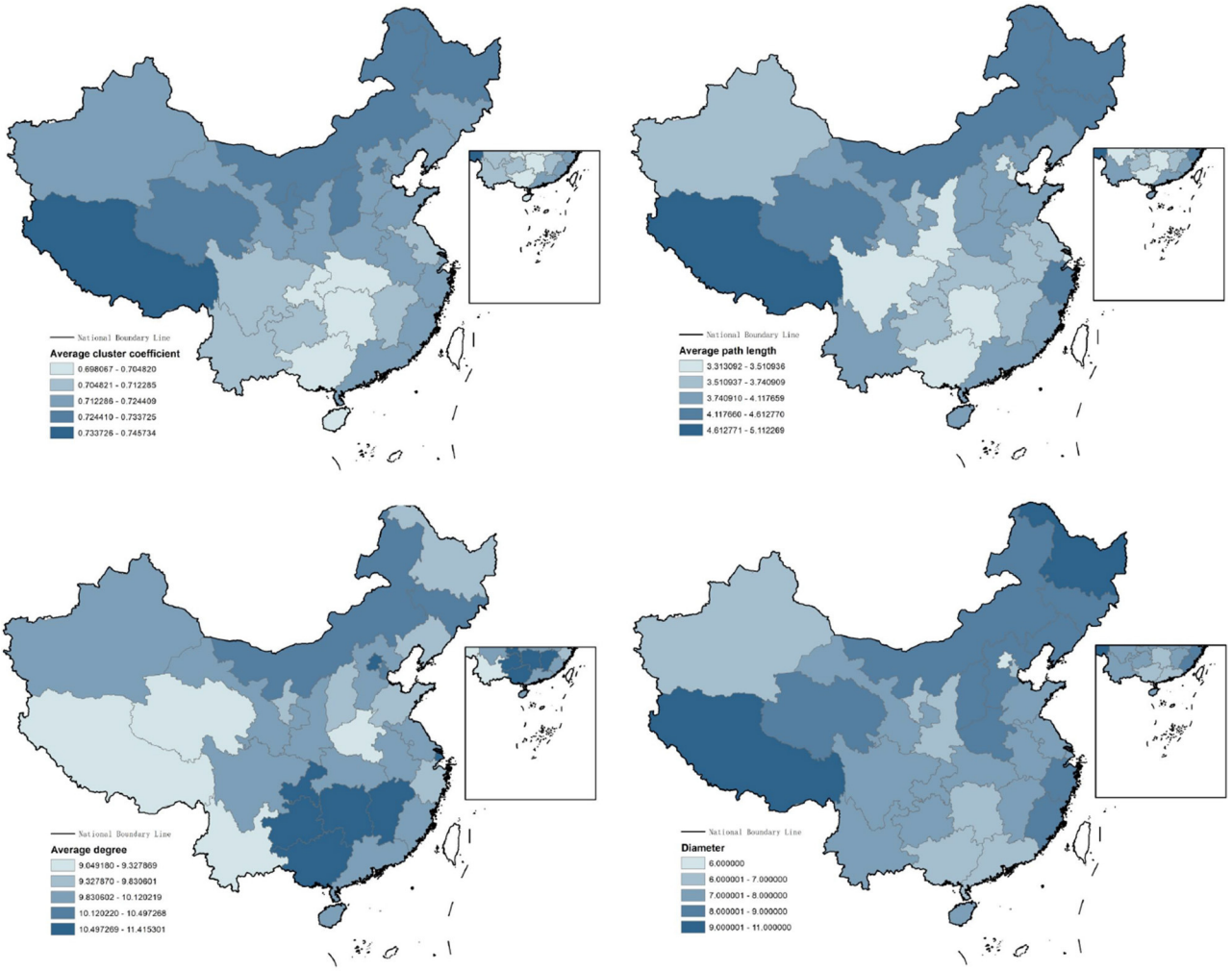

FIGURE 4 | Network characteristics of 30 provinces analyzed through the visibility graph.

in the previous clusters, and a relatively low level of economic development, but a strong industrial base.

From this we can conclude that (1) carbon emissions are closely related to the level of economic development and industrial structure. In the first-tier cities with a very high level of economic development, the secondary industry is not as well developed and emits less carbon. (2) Cities with a higher level of economic development also have relatively high carbon emissions, because they have the basic conditions for industrial development, so they are also divided into the same cluster. (3) Carbon emission levels during the epidemic are distributed in blocks on the ground. It is necessary to take measures from the aspects of industrial structure and transportation mode in combination with carbon trading in neighboring provinces.

4. DISCUSSION

According to this study and the actual situation, firstly, after constructing the visible graph indicator, we found that the degree distribution is long-term correlated with the power-law distribution, that is, the most time nodes have a short range of influence. This shows that the lockdown helps maintain air quality (Barua and Nath, 2021). Changes in total carbon emissions of 30 provinces in 2020, COVID-19 brought short-term emission reductions, especially the impact on the transportation industry is significant (Thu et al., 2020). This is mainly due to the short period of change brought about by the lockdown. However, as the economy recovers, the future trajectory of "post-epidemic" CO2 emissions faces great uncertainty (Hanna et al., 2020). The economic downturn associated with COVID-19 will significantly increase the risk of resuming high-carbon, high-polluting economic activities in the future (Liu et al., 2021a). Therefore, in the post-economic era, reconciling economic recovery with carbon emission reduction is a new challenge for low-carbon economic development. Measures to reduce carbon emissions should be strengthened and stimulated, with a focus on rail transport infrastructure.

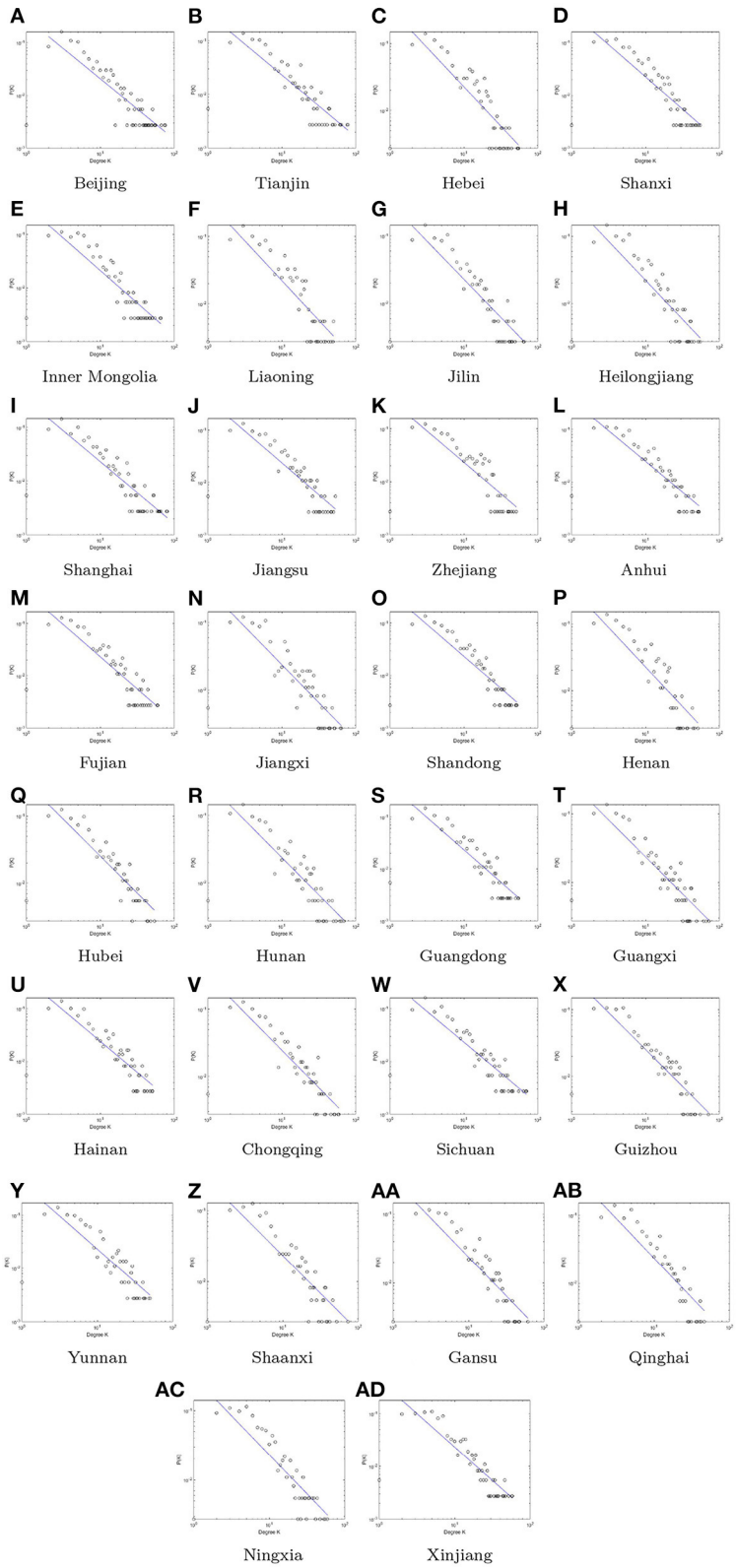

FIGURE 5 | The degree distribution of different provinces in China. **(A)** Beijing, **(B)** Tianjin, **(C)** Hebei, **(D)** Shanxi, **(E)** Inner Mongolia, **(F)** Liaoning, **(G)** Jilin, **(H)** Heilongjiang, **(I)** Shanghai, **(J)** Jiangsu, **(K)** Zhejiang, **(L)** Anhui, **(M)** Fujian, **(N)** Jiangxi, **(O)** Shandong, **(P)** Henan, **(Q)** Hubei, **(R)** Hunan, **(S)** Guangdong, **(T)** Guangxi, **(U)** Hainan, **(V)** Chongqing, **(W)** Sichuan, **(X)** Guizhou, **(Y)** Yunnan, **(Z)** Shaanxi, **(AA)** Gansu, **(AB)** Qinghai, **(AC)** Ningxia, and **(AD)** Xinjiang.

TABLE 3 | The fitting parameters ax^{-b} and goodness of fit R^2 of degree distribution of 30 provinces.

	a	*b*	R^2
Beijing	0.290	1.238	0.614
Tianjin	0.327	1.118	0.659
Hebei	0.336	1.091	0.548
Shanxin	0.378	0.974	0.581
Inner Mongolia	0.349	1.052	0.614
Liaoning	0.337	1.086	0.530
Jilin	0.309	1.176	0.580
Heilongjiang	0.323	1.130	0.550
Shanghai	0.329	1.110	0.676
Jiangsu	0.391	0.940	0.619
Zhejiang	0.357	1.029	0.527
Anhui	0.364	1.009	0.636
Fujian	0.396	0.927	0.637
Jiangxi	0.315	1.156	0.619
Shandong	0.384	0.956	0.595
Henan	0.343	1.071	0.525
Hubei	0.320	1.138	0.610
Hunan	0.302	1.198	0.630
Guangdong	0.411	0.888	0.645
Guangxi	0.283	1.263	0.636
Hainan	0.363	1.014	0.627
Chongqing	0.321	1.137	0.631
Sichuan	0.344	1.068	0.665
Guizhou	0.323	1.130	0.631
Yunnan	0.403	0.909	0.621
Shaanxi	0.268	1.317	0.527
Gansu	0.318	1.146	0.556
Qinghai	0.339	1.082	0.523
Ningxia	0.308	1.177	0.558
Xinjiang	0.432	0.840	0.680

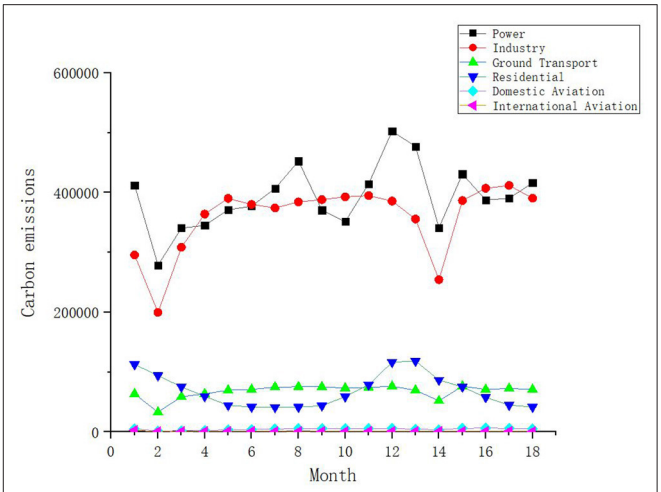

FIGURE 6 | Trends in carbon emissions by sector over the period 2020.1–2021.6.

TABLE 4 | The optimal clustering by k-means.

Cluster	Province
1	Beijing, Shanghai
2	Fujian, Guangdong, Hebei, Anhui, Hubei, Hunan, Jiangxi, Jiangsu, Shandong, Sichuan, Zhejiang
3	Chongqing, Guangxi, Guizhou, Hainan, Henan, Inner Mongolia, Jilin, Qinghai, Shaanxi, Shanxi, Tianjin, Xinjiang, Yunnan
4	Gansu, Heilongjiang, Liaoning, Ningxia

After further combining K-means analysis of indicators such as GDP per capita, passenger traffic and value-added of secondary industries in each province, we find that carbon emissions are closely related to the level of economic development and industrial structure of each province. In first-tier cities with very high levels of economic development have less developed secondary industries and lower carbon emissions. Cities with moderate economic development also have high carbon emissions, because they have the basic conditions for industrial development (Shao and Wang, 2021). Analysis of the data shows that industrial carbon emissions are the main industry in the country (Wang et al., 2021a). Furthermore, the level of carbon emissions during the pandemic is geographically blocky, especially for similar areas such as development at the economic level and industrial structure. Therefore, attention should be paid to carbon trading cooperation in neighboring provinces (Chapman and Tsuji, 2020), energy emission reduction should be coordinated with regional development and innovative development of low-carbon economy and green energy (Balsalobre-Lorente et al., 2020).

Specifically, with the spread of knowledge about the dangers of excessive greenhouse gas emissions, scholars around the world have shown great interest in reducing carbon emissions, developing a low-carbon economy and green energy. N. Absi et al. (2013) propose a multi-quota dynamic scheme for periodic carbon emission constraints in an attempt to achieve carbon emission limits through environmental constraints (Absi et al., 2013). Rui Sims et al. (2003) predict the impact of future technological developments on the cost of electricity generation and total carbon emissions, and suggest that the global power sector needs to improve the reduction of total carbon emissions through fuel switching, CO_2 sequestration and greater use of renewable energy (Sims et al., 2003). It can be found that current research on reducing carbon emissions is focused on two main areas: reducing carbon emissions by improving

carbon performance or shifting existing emission patterns (Rey-Hernández et al., 2020), or by finding new sources of energy using renewable energy (Iqbal et al., 2021; Khanna, 2021).

Finally, we take China's low-carbon economic measures during the COVID-19 pandemic as a reference to provide a new direction for energy conservation and emission reduction (Ionescu, 2021a). In China, to hedge against the impact of COVID-19 and the downward pressure on the economy, provinces across the country are expanding investment in infrastructure, creating a "new infrastructure" in the face of the epidemic (Gosens and Jotzo, 2020). The "new infrastructure" to hedge against the impact of COVID-19 will help transform China's energy structure and reduce CO2 emissions intensity in the following ways (Wang et al., 2020). Firstly, the accelerated construction of ultra-high voltage transmission lines will significantly improve power transmission capacity. Large-span and long-distance power transmission will effectively solve the consumption and output problems of new energy power generation. Secondly, the large-scale construction of new energy charging piles will effectively solve the bottleneck problem in the development of new energy vehicle industry and strongly support the rapid formation and development of China's large-scale electric vehicle market. Thirdly, the "new infrastructure" promotes low-carbon transportation (Zhang et al., 2021). The energy consumption of high-speed trains is much lower than that of aviation, road and high-speed rail transportation will reduce the overall energy consumption and carbon emission intensity of transport. The "new infrastructure" will help China achieve its goal of reaching peak CO_2 emissions by around 2030, with some developed regions taking the lead in reaching the peak.

5. CONCLUSION

Based on complex network analysis and related methods, this paper explores the trend of carbon emissions and its internal logic in 30 Provinces of China during COVID-19. We subdivided the confirmed COVID-19 cases and carbon emissions into provincial daily data, making up for the lagging nature of data, low temporal frequency of data and non-dynamism in previous studies, and explored the characteristic causes of carbon emission changes. The heterogeneity among provinces was studied through K-means. Research shows that COVID-19 has a short time horizon for carbon emissions, and emissions are closely related to regional economic development level and industrial structure, with industrial emissions being the main industry in China. In addition, carbon emission levels are geographically contiguous, which suggests the need to focus on cooperation between neighboring provinces, optimize energy structures and promote the upgrading of "new infrastructure."

The COVID-19 pandemic will not change the long-term trend in carbon emissions, but the unprecedented reduction in carbon emissions due to the lockdown is still worthy of further study. This study also has some limitations. In terms of research data, the number of cases during the lockdown period in China was only combined with some economic indicators, which can be further expanded in terms of covid-19-related indicators and economic indicators. Specifically, this paper suggests a direction for future research: while improved air quality is beneficial to human health, meteorological and climatic factors may be critical to the spread of COVID-19 (Sarwar et al., 2021). This suggests that mortality and morbidity data need to be collected to assess the impact of the measure on overall health. Secondly, the lockdown has important implications for work activities, travel and interpersonal constraints, including the impact on environmental quality. This requires a study of how human activity affects environmental quality, with human activity as the main focus (Marinello et al., 2021). These analyses are beyond the scope of our paper, but future research into these issues is necessary to understand their full implications. Overall, the research in this paper will help other governments make targeted policy decisions based on the COVID-19 pandemic, and draw valuable policy lessons from this unprecedented event while promoting low-carbon economic development.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/**Supplementary Material**.

AUTHOR CONTRIBUTIONS

JH and JC conceived the research. PZ and HL designed the analyses and compiled the data. SH and MW conducted the analyses. SH, MW, and NL wrote the paper. All authors read and approved the final manuscript.

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SUPPLEMENTARY MATERIAL

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Effects of COVID-Induced Public Anxiety on European Stock Markets: Evidence From a Fear-Based Algorithmic Trading System

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The effect of COVID-induced public anxiety on stock markets, particularly in European stock market returns, is examined in this research. The search volumes for the notion of COVID-19 gathered by Google Trends and Wikipedia were used as proxies for COVID-induced public anxiety. COVID-induced public anxiety was shown to be linked with negative returns in European stock markets when a panel data method was used to a sample of data from 14 European stock markets from January 2, 2020 to September 17, 2020. Using an automated trading system, we used this finding to suggest investment methods based on COVID-induced anxiety. The findings of back-testing indicate that these techniques have the potential to generate exceptional profits. These results have significant consequences for government officials, the media, and investors.

Keywords: COVID-19, fear, stock market returns, Google Trends, Wikipedia, algorithmic system trading

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INTRODUCTION

The coronavirus disease (COVID-19) outbreak, which the WHO designated as a pandemic on March 11, 2020, has caused the most major shift in the world order since the previous century, creating economic problems on a scale not seen since the Great Depression of 1929 (Laing, 2020).

Governments all around the globe were confronted with significant difficulties, including a profound economic downturn, rising unemployment, a dramatic decrease in international commerce, and rising budget deficits (Bai et al., 2021). It did not take long for the COVID-19 effect to be felt in the stock market. The rising number of infections has prompted governments to take countermeasures, but it has also resulted in a catastrophic drop in stock markets, with several worldwide markets seeing their worst collapses in history in February and March 2020 (Li et al., 2021). For example, the S&P 500, a stock market benchmark index in the United States, had lost 35% of its value by March 23, 2020, compared to its then-historic high on February 19, 2020.

COVID-19 is the father of all worries that have impacted the world's global financial and economic systems (Phan and Narayan, 2020). According to Aslam et al. (2020), the dread connected with the number of reported fatalities has resulted in a higher level of anxiety and a faster spread of panic than the virus itself. Fear in the stock market has been proven to be a mediator and a transmission route for the COVID-19 epidemic effect (Liu et al., 2020). Investors may overreact or underreact as a result of this anxiety (Daniel et al., 1998; Hong et al., 2007).

Therefore, the purpose of this article is to examine the effect of COVID-induced public anxiety on financial markets, particularly European stock market returns. When individuals are afraid, they tend to look for additional information about the circumstances that have caused them to feel this way (Chen et al., 2019). This study utilized Google Trends and Wikipedia search volumes for the COVID-19 as a foundation for assessing COVID-induced public anxiety. The anxiety generated by COVID-19, as assessed by Google Trends, had a negative and substantial effect on European stock market returns, according to a panel data methodology applied to a sample of 13 nations for the period January 2, 2020 to September 17, 2020. When delays were included in the explanatory factors, the finding was much more robust. Based on the findings, it was thought appropriate to suggest a trading technique to assess the potential to achieve exceptional advantages by integrating fear. Previous research on the impact of COVID-induced public anxiety on stock market returns (Salisu and Vo, 2020) and volatility (Lyócsa et al., 2020) has been conducted. During the COVID-19 epidemic, we utilized Google Trends' forecasting abilities to build an algorithmic trading system. Our findings demonstrated that an algorithmic trading strategy based on COVID-induced public anxiety may generate exceptional gains in European stock markets. To the contribution, (1) we add to the literature on the impact of exogenous events and the ability of internet search volumes to measure the impact of public fear on financial markets; (2) we contribute to studies on the impact of COVID-19 on financial markets by using Google Trends and Wikipedia as indicators of COVID-induced public fear; (3) we show how COVID-induced public fear has a positive impact on financial markets.

This is how the article is organized. The theoretical foundation for the research is discussed in section "Conceptual Framework." Section "Research Methodology" includes the data and suggested approach. The findings are presented and discussed in section "Results and Discussion." Finally, in section "Conclusion," the study's findings are presented.

CONCEPTUAL FRAMEWORK

Since the 1918 Spanish Flu epidemic, the COVID-19 has been a significant worldwide danger to life and livelihood (Zhou et al., 2020). This time, the fast spread of the virus and high death rates sparked widespread public worry, resulting in anxiety and even panic, independent of geography or COVID-19 exposure (Nicomedes and Avila, 2020). Multiple studies on COVID-19's impact on geopolitical risk (Sharif et al., 2020), the economy (Jordà et al., 2020; Mohsin et al., 2021), labor markets and employment (Coibion et al., 2020), large companies (Hassan et al., 2020), and small business (Fairlie, 2020) have been published in a short period of time. Studies by Al-Awadhi et al. (2020) and Liu et al. (2020) in financial markets revealed evidence of the rapid effect of verified COVID-19 cases and fatalities in these markets. Several researches have looked at the effect of COVID-19-induced negative emotion on stock market performance from a behavioral finance viewpoint. Bansal (2020) investigated the impact of cognitive mistakes and biases on financial institutions and markets during and after the COVID-19 crisis. Mann et al. (2020) looked at demographic and individual relationships for distress anxiety, the day after the COVID-19 pandemic announcement caused record stock market collapses. When individuals encounter financial problems, they found that age, location, children, self-esteem, awareness, openness to experience, neuroticism, susceptibility to disease, and group participation were deciding variables in anxiety levels. Zaremba et al. (2020) looked at the effect of government actions to limit the spread of COVID-19 on stock market volatility and found that non-pharmaceutical measures increased stock market volatility substantially. They discovered that this impact was independent of the COVID-19 pandemic's involvement, and that it was resilient to a variety of factors. In response to COVID-19 pronouncements, Erdem (2020) investigated the potential connection between a country's degree of freedom and stock performance, and discovered that the detrimental impacts of the COVID-19 on stock markets were smaller in the freest nations. Salisu et al. (2020a) investigated how developing stock markets react to the risk of pandemics and epidemics, such as the COVID-19 pandemic. Emerging stock markets, they discovered, are more susceptible to the unpredictability of pandemics and epidemics than established stock markets (Sun and Li, 2021). The COVID-19 danger came as a surprise, prompting individuals to look for additional information about the pandemic. People pay greater attention to the current news and significant events as an infectious illness spread, and they search the internet for disease-related terms (Chen et al., 2019; Shang et al., 2021). High-impact incidents, such as COVID-19, often get a lot of media attention, resulting in heightened public anxiety (Tulloch and Zinn, 2011; Young et al., 2013; Sun et al., 2021) and long-term repercussions (Tulloch and Zinn, 2011; Young et al., 2013). The connection between the media and financial markets has been well-documented in the literature for decades (e.g., Barberis et al., 1998; Tetlock, 2007). Akıncı and Chahrour (2018) and Cohen et al. (2018) have supported the so-called "bad news principle," which states that only negative news affects investment choices. However, some writers argue that good news may equally influence investment decisions (Narayan and Bannigidadmath, 2015; Narayan, 2019). Technological advancements and the ease with which individuals may access the internet have resulted in the availability of a huge quantity of information that people can access on a daily basis. Several social phenomena have been tracked using web search traffic (Choi and Varian, 2012). People's thinking has shifted as a result of mass online activity (Preis et al., 2012; Moat et al., 2014), and a new science of collective decision making has emerged. Online sources have been used as proxies in finance research to explain the collective behavior of financial markets (Heiberger, 2015; Nguyen et al., 2019; Tan and Taş, 2019). Several indicators were utilized, including Yahoo online search traffic (Bordino et al., 2012), Twitter activity (Zhang et al., 2011; Mathiesen et al., 2013), Google Trends (Kristoufek, 2013; Asif Khan et al., 2019; Nguyen et al., 2019), and Wikipedia activity (Nguyen et al., 2019). Google Trends' explanatory power for the effect of COVID-induced public anxiety on stock market returns has been evaluated in a stress scenario. This issue has been addressed in recent literature. Costola et al. (2020) looked at the

dynamics of public concern in Italy, the first European nation to suffer a COVID-19 epidemic, using three search-engine data from Google Trends. According to their research, public worry in Italy is a driver of public concern in other countries, and Google Trends data for Italy better explain stock index returns in other countries when compared to country-based variables. Similarly, Liu (2020) found that the negative COVID-19 effect on China's composite index varied by industry based on daily Google Trends search data. Smales (2020) demonstrated how increased attention to COVID-19, as assessed by Google Search Volumes, impacted United States market returns adversely. Increased Google Trends synthetic index for COVID-19 has a direct and indirect impact on implied volatility and stock returns, according to Papadamou et al. (2020), with the effects being greater in Europe than the rest of the globe. Meanwhile, Wikipedia has not gotten the same amount of attention as Google Trends as a proxy for measuring investor anxiety, despite some evidence from the literature. Cergol and Omladič (2015) demonstrated that Wikipedia entries for stock prices exhibit an inverted pattern of a "merry frown" for the bear market and a "sour grin" for the bull market. Hervé et al. (2019) investigated the connection between Wikipedia records and the conduct of noise traders, finding that solely the attention of noise traders affects stock returns and increases volatility. After reviewing prior research and interpreting fear as a collective behavior arising from an outburst of public concern over an issue (Loewenstein et al., 2001), the following is suggested as the study's initial hypothesis being put to the test.

H01: Public anxiety caused by COVID lowers European stock returns.

One key issue is whether COVID-induced public dread, in addition to being harmful, is also beneficial having the ability to explain stock market returns also means being able to forecast them in the future a wide range of options are available. There has been research on the predictive power of many internet sources, such as: Twitter sentiments (Bollen et al., 2011), stock micro-blog sentiments (Oh and Sheng, 2011), Google Trends (Preis et al., 2013; Bijl et al., 2016; Tan and Taş, 2019), and Wikipedia search volumes (Curme et al., 2014). Google Trends is one of the most widely used indicators, not only because of its explanatory power (Heiberger, 2015; Yu et al., 2019), but also because of its utility as a source of data for quantifying trading behavior (Preis et al., 2013), earnings announcements (Drake et al., 2012), and international equity holdings (Mondria et al., 2010). Changes in Wikipedia page views offered information for investors to make choices before stock trading, according to Moat et al. (2013) in finance. Weng et al. (2018) examined conventional stock technical indicators in combination with internet data sources (such as Google and Wikipedia) to forecast short-term stock prices using a large sample of firms from the S&P 500 Index. They demonstrated that using internet data sources improves stock price prediction in their research. The epidemic has given an excellent opportunity to review the predictive potential of online-based measures and put them to the test in a stressful situation. Salisu and Vo (2020) demonstrated the predictive potential of Google Trends by using health-news searches adjusted for macroeconomic variables and incorporating financial news in the prediction of stock returns, both using Google's search engine. Lyócsa et al. (2020) used Google search traffic as a predictor of anxiety and dread words relating to the COVID-19 outbreak and non-pharmaceutical terms physical contagion intervention policies Their findings supported the belief that fear is a real thing the COVID-19's product is an excellent predictor of stock market fluctuations. Wikimedia Commons there have been no studies based on Wikipedia search volumes that we are aware of stock market performance may be predicted using COVID-19. The study second hypothesis, based on the above, is as follows:

H02: Public panic caused by COVID may be used to forecast European stock returns.

Several researches have designed trading techniques based on the data discovered about the predictive potential of internet search traffic. We are aware that there is just a small body of research that looks into Google Trends and/or Wikipedia data in this context in particular. Curme et al. (2014) suggested trading methods based on the data created by internet users while looking for information online utilizing the Google search engine and the Wikipedia encyclopedia. They pointed out that search levels in the areas of politics and business were effective in foreseeing events in the stock markets subsequent moves, in particular, they demonstrated how these searches anticipated future market declines. According to Bijl et al. (2016), the high number of Google searches for publicly traded businesses results in negative returns stocks. As a result, these writers looked into a trading strategy that included selling high-yield equities. Purchasing equities with low Google search volume vs. buying stocks with high Google search volume. They showed how these techniques might provide positive returns even when transaction expenses were taken into account. Gómez et al. (2018) suggested the use of Google search volumes to build algorithmic trading systems based on different financial keywords. They discovered that the number of Google searches is a useful indicator for gauging worldwide investor sentiment in their research. Dickerson (2018) demonstrated a very successful algorithmic trading method for trading Bit-coin based on Wikipedia and Google search traffic. ElBahrawy et al. (2019) discovered that, when compared to baseline methods, a basic trading strategy based on Wikipedia's opinions on digital currencies provided substantial returns on investment. The third hypothesis to be investigated, based on the literature, is as follows:

H03: A Google Trends and Wikipedia-based algorithmic trading system may provide significant advantages.

Based on the limitations in the research, this study will attempt to fill those gaps by assessing the explanatory and predictive capacity of COVID-induced public anxiety using Google Trends and Wikipedia as search engines. Furthermore, this research suggests incorporating COVID-19's fear into the design of an algorithmic trading system. This is the only research that we are aware of that suggests a trading system based on COVID-induced public anxiety utilizing internet search levels as proxy for this concern.

TABLE 1 | Countries and stock indices taken as reference points.

Country	Stock index
Spain	IBEX 35
United Kingdom	FTSE 100
Greece	Athens General Composite
Poland	WIG 20
Germany	DAX 30
Romania	BET
Portugal	PSI 20
Netherlands	AEX
Turkey	BIST 100
France	CAC 40
Belgium	BEL 20
Italy	FTSE MIB

RESEARCH METHODOLOGY

A sample of daily data was collected from January 2, 2020 to September 17, 2020 in order to examine the impact of public anxiety created by COVID-19 on the recovery of European stock markets.

In this research, we suggested two indicators as proxy for Internet users' behaviors to assess public dread. On the one hand, Google Trends[1] (Fear1) internet search data was chosen using the same techniques as Chen et al. (2020) and Lyócsa et al. (2020). Google Trends provides a free and public query index that depicts search volume as a number between 0 and 1. Hundreds of categories may be used to categories data, such as geographic location activities, and so on. The "search by subject" option was selected for our research, and the topic "COVID-19" was chosen. Instead of an introduction, the COVID-19 subject contained questions about the virus precise phrase. This subject allows for a variety of synonyms, spelling mistakes, and grammatical blunders to be included in the study due to translations from other languages (Szmuda et al., 2020). In addition, Wikipedia search data[2] (Fear2) was used additionally chosen. Researchers have looked at prediction models based on Wikipedia queries. Mestyán et al. (2013) and Moat et al. (2013) are examples of earlier authors (2013). Look up something on Wikipedia. Page views analysis has volumes accessible, and each extracted data set

[1]https://trends.google.com/trends/

[2]https://pageviews.toolforge.org/

TABLE 2 | Influence of COVID-induced public fear on European stock market returns.

Variable	R_{1i}				R_{1i}			
	Coef.	S.D.	*Z*	*p*-value	Coef.	S.D.	*z*	*p*-value
Const	−0.00035	0.00035	−3.543	0.305	−0.00035	0.00037	−3.490	0.335
d.Fear3t	−0.00033	3.35e-5	−9.737	0.000***				
d.Fear3t					−7.95e-5	0.00030	−0.408	0.583
$Gold_t$	0.08953	0.02438	7.937	0.000***	0.30393	0.03340	9.330	0.000***
VIX_t	−0.04395	0.00355	−38.42	0.000***	−0.04530	0.00357	−39.50	0.000***
TV_t	0.00033	0.00073	0.58	0.495	−0.00073	0.00038	−0.353	0.567
Durbin Watson test			3.35455				3.43837	
Hausman			0.57053				0.44539	
Test			−0.955				−0.864	
Obs.			3,690				3,690	

****indicate the significance at 3, 5, and 30% levels, respectively.*

TABLE 3 | Influence of COVID-induced public fear on European stock market returns.

Variable	R2i				R2i			
	Coef.	S.D.	*Z*	*p*-value	Coef.	S.D.	*z*	*p*-value
Const	−0.00034	0.00016	−1.631	0.105	−0.00025	0.00017	−1.490	0.136
$d.Fear_{1t}$	−0.00047	3.34e-5	−9.717	0.000***				
$d.Fear_{2t}$					−7.95e-5	0.00020	−0.408	0.821
$Gold_t$	0.08951	0.02478	7.937	0.000***	0.10383	0.02340	9.120	0.000***
VIX_t	−0.04386	0.00373	−38.33	0.000***	−0.04620	0.00367	−29.50	0.000***
TV_t	0.00031	0.00047	0.72	0.495	−0.00012	0.00047	−0.362	0.717
Durbin Watson test			2.36445				2.13838	
Hausman			0.63083				0.48979	
Test			−0.875				−0.885	
Obs.			3,690				3,690	

****indicate the significance at 1, 5, and 10% levels, respectively.*

displays the total amount of data collected by users in a single day across the globe. Similarly, the subject of discussion was "COVID-19," however, unlike Google, Wikipedia did not provide statistics by nation. Google Trends is a tool that allows you to see how COVID-induced public anxiety affects the European stock market. This research includes nations that are members of the European Union and have a population of more than one million people, a city with a population of more than ten million people and those with a thriving stock market and a representative index were chosen. As a result, for the nations who fulfilled these criteria and had sufficient stock, investing[3] provided market data, including stock prices. Their main stock indexes were utilized in the analysis. **Table 1** lists the nations and stock indexes that were chosen. They showed how these techniques might provide positive returns even when transaction expenses were taken into account. Gómez et al. (2018) suggested the use of Google search volumes to build algorithmic trading systems based on different financial keywords. They discovered that the number of Google searches is a useful indicator for gauging worldwide investor sentiment in their research. Dickerson (2018) demonstrated a very successful algorithmic trading method for trading Bit-coin based on Wikipedia and Google search traffic. ElBahrawy et al. (2019) discovered that, when compared to baseline methods, a basic trading strategy based on Wikipedia's opinions on digital currencies provided substantial returns on investment. The third hypothesis to be investigated, based on the literature, is as follows: H03: A Google Trends and Wikipedia-based algorithmic trading system may provide significant advantages. Based on the limitations in the research, this study will attempt to fill those gaps by assessing the explanatory and predictive capacity of COVID-induced public anxiety using Google Trends and Wikipedia as search engines. Furthermore, this research suggests incorporating COVID-19's fear into the design of an algorithmic trading system. This is the only research that we are aware of that suggests a trading system based on COVID-induced public anxiety utilizing internet search levels as proxy for this concern.

[3]https://es.investing.com/

Research Designs

We decided not to use the cointegration analysis since all variables were not integrated in the same order, as Enders (2004) suggested. To remove the unit root issue caused by the use of non-stationary variables, we suggested that differences are to be entered into non-stationary variables in this research to address the spurious regression problem (Montero, 2013). In this research, we suggested a panel data method with all stationary variables. When the data provided included a temporal and a transversal dimension, this method allowed for the assessment of the explanatory power of certain variables over others, making it a more suitable approach than transversal analysis and time series analysis in this situation (Wooldridge, 2011). The fixed effects model and the random effects model are the two primary models used in panel data technique. The individual impact is assumed to be associated with the explanatory variables in the fixed effects model. The random effects model, on the other hand, implies that individual effects are unrelated to the model's explanatory factors. The use of the Hausman test (Hausman, 1978) was critical in determining which model was most suitable. This test determined if the panel data model's determinants were more consistent whether using the fixed effects model *versus* the random effects model. The findings of the Hausman test indicated whether or not

TABLE 4 | The targeted variables' descriptive statistics.

Variable	Mean	Median	Minimum	Maximum	S.D.	C.V
R_1	−0.00097	0.00069	−0.16914	0.10976	0.01149	14.569
R1	−0.00049	0.00027	−0.09061	0.04616	0.00649	19.701
$Fear_1$	16.77	10	0	100	17.491	1.1091
Fear1	2.17E + 05	19,861	907	9.92E + 05	1.95E + 05	1.4976
Gold	0.0016	0.0016	−0.0469	0.0677	0.01417	10.961
VIX	0.00764	−0.011	−0.1667	0.4796	0.10499	16.764
TV	0.06996	−0.00476	−0.91591	9.9165	0.60436	7.134

Critical value at 6% (two-tailed) = 0.0400.

TABLE 5 | Results of bivariate correlations of the targeted variables.

Variable	R_1	R7	$Fear_1$	Fear7	Gold	VIX	TV
R_1	1	0.1474	−0.1607	−0.1573	0.1704	−0.4147	−0.0734
R7		1	−0.154	−0.1476	0.171	−0.4704	−0.066
$Fear_1$			1	0.4447	−0.1164	0.0634	−0.0053
Fear7				1	−0.0477	0.7044	0.0073
Gold					1	−0.0457	0.0047
VIX						1	0.1471
TV							1

Critical value at 5% (two-tailed) = 0.0400.

the random effects model should be used (**Tables 2**, **3**). As a result, the following panel data models were suggested to investigate the impact of COVID-induced public anxiety on European stock market returns:

$$R_{1it} = \alpha + \beta_1 d.Fear_{1it} + \beta_2 Gold_{it} + \beta_3 VIX_{it} + \beta_4 TV_{it} + w_i + \varepsilon_{it}, t = 1, 2, \ldots, T \quad (1)$$

$$R_{1it} = \alpha + \beta_1 d.Fear_{2it} + \beta_2 Gold_{it} + \beta_3 VIX_{it} + \beta_4 TV_{it} + w_i + \varepsilon_{it}, t = 1, 2, \ldots, T \quad (2)$$

$$R_{2it} = \alpha + \beta_1 d.Fear_{1it} + \beta_2 Gold_{it} + \beta_3 VIX_{it} + \beta_4 TV_{it} + w_i + \varepsilon_{it}, t = 1, 2, \ldots, T \quad (3)$$

$$R_{2it} = \alpha + \beta_1 d.Fear_{2it} + \beta_2 Gold_{it} + \beta_3 VIX_{it} + \beta_4 TV_{it} + w_i + \varepsilon_{it}, t = 1, 2, \ldots, T \quad (4)$$

Where R_{1it} and R_{2it} are the dependent variables of the models, α is the constant term, β_k is the regression coefficient of each explanatory variable k, w_i is a random variable of the individual effects, and ε_{it} is the error term.

Data Collection Method

A sample of daily data was collected from January 2, 2020 to September 17, 2020 in order to examine the impact of public anxiety created by COVID-19 on the recovery of European stock markets. In this research, we suggested two indicators as proxy for Internet users' behaviors to assess public dread. On the one hand, Google Trends (see text footnote 1) (Fear1) internet search data was chosen using the same techniques as suggested by Chen et al. (2020) and Lyócsa et al. (2020). Google Trends provides a free and public query index that depicts search volume as a number between 0 and 1. Hundreds of categories may be used to categorize data, such as geographic location activities, and so the "search by subject" option was selected for our research, and the topic "COVID-19" was chosen. Instead of an introduction, the COVID-19 subject contained questions about the virus precise phrase this subject allows for a variety of synonyms, spelling mistakes, and grammatical blunders. To be included in the study are translations from other languages (Szmuda et al., 2020). In addition, Wikipedia search data (see text footnote 2) (Fear2) was used additionally chosen Researchers have looked at prediction models based on Wikipedia queries. Mestyán et al. (2013) and Moat et al. (2013) are examples of earlier authors (2013). Look up something on Wikipedia. Page views Analysis has volumes accessible, and each extracted data set displays the total amount of data collected by users in a single day across the globe. Similarly, the subject of discussion was "COVID-19," however, unlike Google, Wikipedia did not provide statistics by nation. Google Trends is a tool that allows you to see how COVID-induced public anxiety affects the European stock market. This research includes nations that are members of the European Union and have a population of more than one million people, a city with a population of more than ten million people and those with a thriving stock market and a representative index were chosen. As a result, for the nations who fulfilled these criteria and had sufficient stock, investing (see text footnote 3) provided market data, including stock prices. Their main stock indexes were utilized in the analysis. **Table 1** lists the nations and stock indexes that were chosen.

To achieve better soundness in the obtained findings, we chose two variables of stock index returns to assess stock returns. The rate of change in the closing price of a stock index over 2 days was the first metric utilized.

$$S_{1it} = \frac{S_{it} - S_{i,t-1}}{S_{i,t-1}} \quad (5)$$

Where S_{1it} is the return of the stock index i on day t as calculated using eq. (5), and S_{it} is the index's closing price on day t. The logarithm of the ratio of the closing prices over two consecutive days was the second measure of stock returns.

$$S_{2it} = \log\left(\frac{S_{it}}{S_{i,t-1}}\right) \quad (6)$$

Where S_{2it} is the return of index I on day t, calculated using eq. (6), and control factors linked to the COVID-19's effect on stock market results were also examined. Gold returns (Cepoi, 2020; Gherghina et al., 2020), the rate of change of the volatility index (VIX) (Liu et al., 2020; Salisu et al., 2020b),

TABLE 6 | The predictive capacity of the COVID-induced public fear of the European stock markets 24 return.

Variable	z	Z	Z	Z
	Coef. (*p*-value)	Coef. (*p*-value)	Coef. (*p*-value)	Coef. (*p*-value)
Const	−2.01**	−1.84*	−2.52**	−2.34**
	−0.0009	−0.0008	−0.0005	−0.0005
	−0.044	−0.066	−0.012	−0.019
$d.Fear_{1t-1}$	−8.69***		−8.75***	
	−0.0008		−0.0003	
	0		0	
$d.Fear_{2t-1}$		−0.75		−0.71
		−0.0004		−0.0002
		−0.452		−0.477
$Gold_{t-1}$	2.96***	4.07***	2.90***	4.02***
	0.0901	0.1247	0.039	0.0544
	−0.003	0	−0.004	0
VIX_{t-1}	−3.68***	−4.93***	−3.72	−4.97***
	−0.0154	−0.0207	−0.0069	−0.0092
	0	0	0	0
TVt-1	0.58	−0.3	0.67	−0.27
	0.0005	−0.0003	0.0003	−0.0001
	−0.564	−0.719	−0.502	−0.785
Durbin Watson	2.31524	2.22535	2.31838	2.22512
Hausman test	0.4119	0.3318	0.4487	0.3868
Test	−0.982	−0.988	−0.978	−0.98355
Obs.	3,690	3,690	3,690	3,690

****, **, and * indicate the significance at 1, 5, and 10% levels, respectively.*

and the rate of change of trading volume (TV) were utilized as control variables in this research (Huo and Qiu, 2020; Zaremba et al., 2020). The descriptive statistics for the variables under investigation are shown in **Table 4**. In terms of stock return metrics, the findings showed that throughout the research period, the average daily return was negative, with the lowest return occurring on March 12, 2020, when the Italian market saw a price drop of −16.924%. According to Google Trends, the greatest COVID-induced public panic occurred between March 11 and 18, whereas the highest Wikipedia search traffic occurred on January 27. Using the control variables as a guide, the findings revealed that gold maintained a positive return throughout the study period, reaching a high of 5.77% on March 23.

The VIX reached its highest rate of change of 47.87% on June 11, 2020, while the Romanian market saw its maximum and lowest rate of change of TV on February 24 to August 18, 2020, respectively. When looking at the dispersion, it is clear that stock returns have the greatest dispersion of the variables examined. The relationships between the various target research variables are shown in **Table 5**. It demonstrates how the suggested return measures were negatively associated with COVID-induced public anxiety (both Fear1 and Fear2), the VIX index, and TVs, whereas gold returns were favorably correlated. Concerning the representative measures of COVID-induced public anxiety, it is discovered that, as one would expect, both measures are positively linked. These indicators also have a negative relationship with gold returns and TVs, but a positive relationship with the VIX index.

RESULTS AND DISCUSSION

The results obtained in the study with the proposed models. **Table 2** shows the findings of a study that looked at the effect of COVID-induced public dread ($d.Fear_{1t}$ and $d.Fear_{2t}$) on European stock market returns, taking the rate of change of the

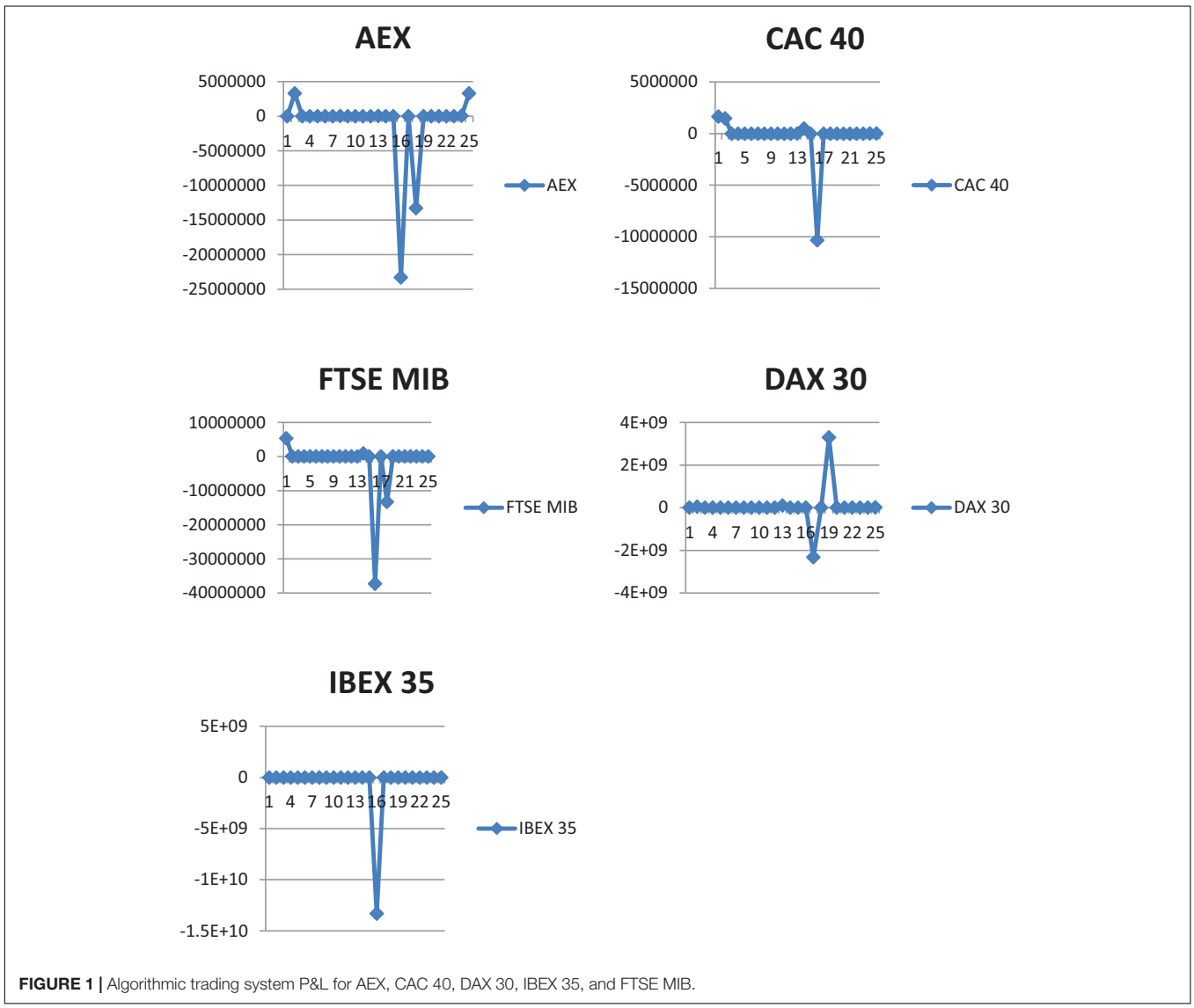

FIGURE 1 | Algorithmic trading system P&L for AEX, CAC 40, DAX 30, IBEX 35, and FTSE MIB.

market price into account (R_{1t}). With over 99.9% confidence, COVID-induced public anxiety, as assessed by Google Trends, was shown to have a negative and substantial effect on European stock indexes' returns. When the control factors were taken into account, gold returns had a positive and substantial effect on European stock market returns, whereas the VIX index variation had a negative and significant impact. TVs, on the other hand, had no discernible impact. Although the coefficient of COVID-induced public anxiety assessed by Wikipedia searches ($d.Fear_{2t}$) had a negative value, it cannot be stated that the coefficient had a value different from 0.

The restriction of Wikipedia's search level extraction may be one of the explanations for this finding. It was not feasible to extract the level of searches for the COVID-19 subject by nation, as stated in the data section. Only global detail was available on the platform. As a result, although COVID-induced public dread may vary by nation, the limits of the global metric based on Wikipedia may not properly represent COVID-19-related fear in a given country's population. When we look at the findings for the models suggested around the second measure of the return, R_{2t} (**Table 3**), we see that they are comparable to those in **Table 2**. The models satisfy the residuals' uncorrelated and homoscedasticity in both instances, demonstrating how COVID-induced public anxiety, as assessed by Google search volumes, has a negative and substantial effect on European stock market returns. Similarly, it was discovered that the reference based on Wikipedia search volumes had no meaningful impact on stock market results. H01 can be accepted based on the results obtained when evaluating the impact of COVID-induced public fear on European stock market returns using $d.Fear_{2t}$, which show that increases in fear caused by the COVID-19 resulted in lower European stock market returns. These findings matched with Costola et al. (2020), Liu (2020), Papadamou et al. (2020), and Smales (2020) specification of the variables, which was modified to check the robustness of the analysis, taking into account the lagged ones to validate the results.

We looked at the effects of the explanatory variables at time t-1 on stock market returns at time t in particular. As a result, this specification not only assesses the robustness of our findings, but also the ability of COVID-induced public fear to predict next-day stock market returns. **Table 6** shows the results of applying a lag to the proposed models' explanatory variables. When using Google Trends as a reference, it can be seen that even after applying a lag, COVID-induced public fear continues to have a significant inverse relationship with stock market returns with more than 99.9% confidence. When it came to Wikipedia search volumes, however, there was no discernible influence. Similarly, the variables of gold returns and VIX index variation maintained

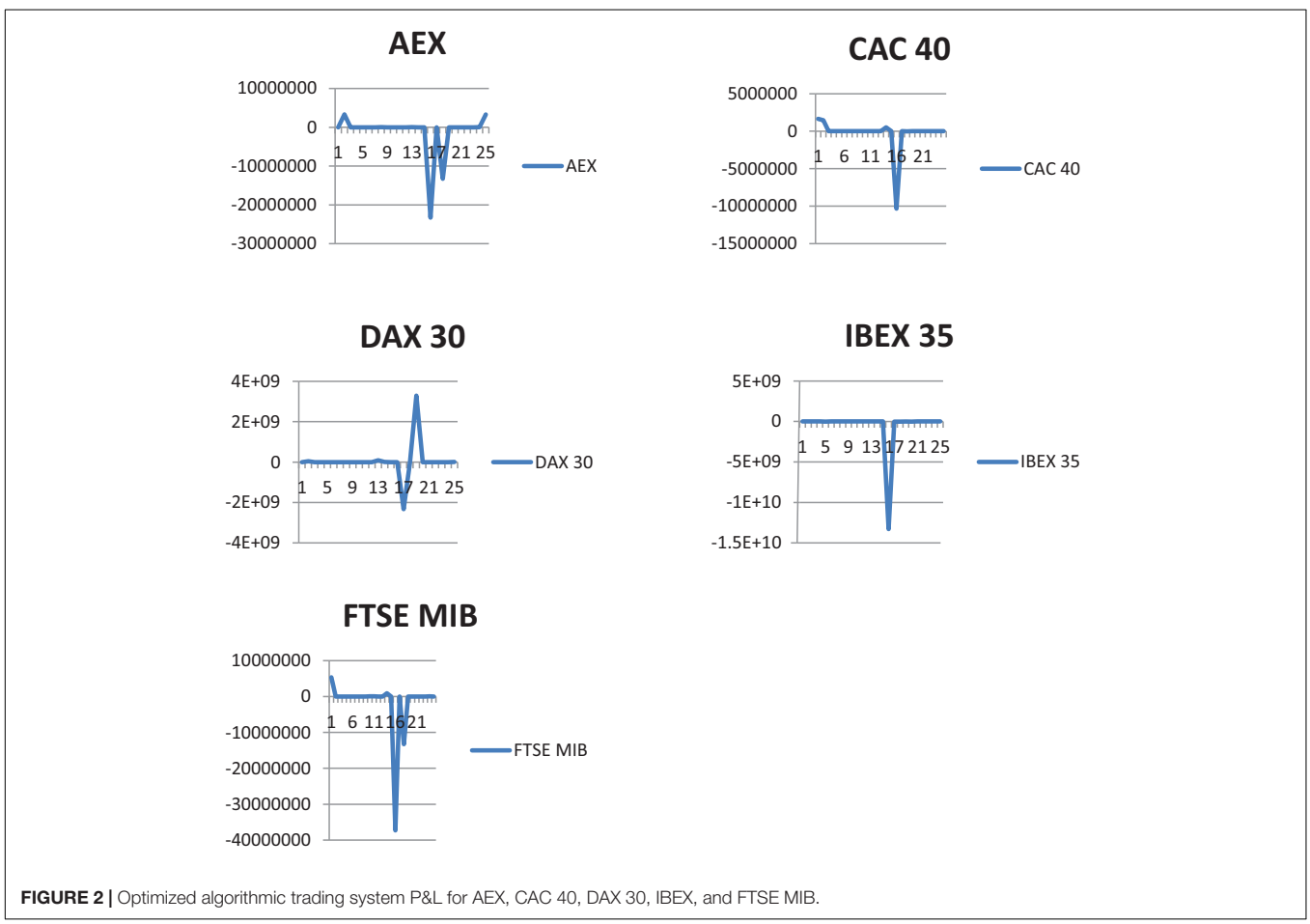

FIGURE 2 | Optimized algorithmic trading system P&L for AEX, CAC 40, DAX 30, IBEX, and FTSE MIB.

the relationship established in previous models. As a result, these findings show that COVID-induced public fear not only explains but also predicts the return of European stock markets, allowing H02 to be accepted. The validation of this research hypothesis backs up Lyócsa et al. (2020) and Salisu and Vo (2020) conclusions about this metric's predictive power. This research aims to take things a step further by using the findings so far. After demonstrating that COVID-induced public fear explains and forecasts a portion of the performance of European stock markets, we looked into the potential of making huge gains by investing in these markets based on COVID-induced public fear.

The use of Wikipedia search volumes was ruled out owing to the absence of correlation between Wikipedia search volumes and stock returns. As a result, the initial model suggested used Google search volumes (Eq. 7) in conjunction with the lag of explanatory factors whose effect on stock market returns was shown to be substantial. An algorithmic trading system was utilized in the suggested system architecture to make investment choices based on the following equation:

$$R_{1it} = -0.000847037 - 0.000756169 \cdot d.Fear_{1it-1} + 0.0905054 \cdot Gold_{it-1} - 0.0150954 \cdot VIX_{it-1} \quad (7)$$

Using the preceding equation as a guide, we created an algorithmic trading system that worked as follows:

- If the equation's result was positive, open a long position in the index's future at the start.
- If the equation's outcome was negative, open a short position in the index's future.
- At the conclusion of the trading session, all open positions were closed.

We used the Trading Motion platform[4] to conduct these back tests. The Trading Motion has been providing automated trading systems from various developers to clients *via* more than 20 brokers across the globe since 2002.

In terms of the European market, this platform enables you to trade the following indices: AEX, CAC 40, DAX 30, IBEX 35, and FTSE MIB. As a consequence, we examined the outcomes of applying the suggested model to these five indices. **Figure 1** shows the Profit and Loss (P and L) graphs produced after the specified procedure. The trading algorithms beat the market for all indices throughout the research period and were profitable during the epidemic phase that corresponded with the large lockdowns. However, it was discovered that the system's performance suffered as a consequence of the return to normalcy.

As a result, the system needed to be optimized. We only examined two criteria to prevent over-optimization: closing positions when a profit of 1% was reached and the system only operating when the equation produced a result higher than 0.25%. **Figure 2** shows the P and L charts of the optimized systems. It can be shown that using the optimized trading system resulted in improved performance not only just during the

[4]https://www.tradingmotion.com/

TABLE 7 | Summary of the improved trading system performance.

Indicator	AEX	CAC 40	DAX 30	IBEX 35	FTSE MIB
Net P&L	2929.5329	1655037.29	59215.15	5150	5345037.1
Gross P&L	3290290	1465400	42536505.5	5050	5370
Profit factor	1.1346	1.1329	2.05	1.29	1.19
Sharpe ratio	0.29	0.29	2.95	1.59	0.5329
Slippage per side	−0.05	−0.29	−1.1329	−1	−0.05
Net P&L over	5.03%	5.95%	29.92%	32903290.33%	11.29%
Drawdown	0.37	0.29	5.59	1.51	0.32901
Mathematical expectation	34509.54	19.52	345.5	43.37	59.25
Analyzed sessions	151	190	159	190	151
Sessions in market	29	29	29	29	53290
Winning sessions	25	29	32905	25	32900
Success rate	29.29%	53290.05%	29.52%	52.37%	29.50%
Winning sessions profit	37909.51	11500.09	95034305.29	19250	25110.29
Average losing sessions	929.1329	503290.29	3793290.29	295.21	903290.59
Losing profit sessions	20	15	20	15	23290
Sessions profit	−23290491.99	−10329029.53	−29295.52	−13290132900	−37293290.29
Average worst sessions	−1152.5	−510.29	−2329053291	−292.32905	−990.59
Drawdown best sessions	−13290537.09	−2950.01	−11025.29	−5329050	−13290295.52
Worst sessions	1195	295.91	3290329026	932900	1195
	−3795.52	−1291.25	−11025.29	−2150	−3715.52
30 days volatility	132905.29%	50.37%	32900.52%	29.90%	95.95%
1 year volatility	0.00%	0.00%	0.00%	0.00%	0.00%
5 years volatility	0.00%	0.00%	0.00%	0.00%	0.00%
Suggested capital	52000	19000	120000	25000	50000
Required capital	3290500	2000	13290500	2500	2500

pandemic's containment phase, which corresponded with large lockdowns, but also after the closures were lifted. **Table 7** shows the performance of the improved algorithmic trading system. We can observe that the five optimized systems had a positive gross and net return. The profit factor was higher than one, and the proportion of winning sessions was greater than 50%, both of which are considered lucrative levels. As a result, all of the annualized return on investments (ROIs) in **Table 7** are positive. The ROI was determined by dividing the net P and L by the capital positions recommended by stockbrokers.

The results support H03 by showing that exceptional gains may be obtained *via* algorithmic trading systems based on COVID-induced public anxiety. Previous studies such as Curme et al. (2014), Bijl et al. (2016), Dickerson (2018), and Gómez et al. (2018) found good performance of trading systems based on the level of Google searches, and this study adds new evidence of the possibility of considering COVID-induced public fear in the construction of algorithmic trading systems.

CONCLUSION

The announcement of the COVID-19 pandemic was the most important worldwide shift since the turn of the century. Stock markets fell sharply as a result of the pandemic, with the most severe drops in the history of world financial markets occurring in February and March 2020. Because of the effect of COVID-19's ramifications on stock prices, this research was conducted. We examined the effect of COVID-induced public anxiety on European stock markets in markets here are market returns. In accordance with prior research, when a population feels frightened, they become more aggressive. They are more likely to seek knowledge about the incident that causes them to feel this way and regarded COVID-19 search volumes on Google and Wikipedia as adequate. COVID-induced public anxiety is represented by proxies from January 2, panel data analysis was used on a sample of 13 European nations. We demonstrated that COVID-induced public anxiety, from September 17, 2020 to September 17, 2020, had a negative and substantial effect on Google search volumes, as assessed by Google search volumes. Returns on European stock exchanges using the number of searches on Wikipedia as a proxy for fear COVID-19, number, was determined to have no effect. These findings were unaffected by the addition of a lag in the explanatory factors, showing the explanatory variables' predictive ability models that have been suggested, and another significant aim stated in this research was the goal of obtaining exceptional gains from algorithmic trading based on COVID-induced public anxiety systems. The ability of internet searches to explain and forecast has been extensively discussed, and the searches have been investigated, although there is scant evidence of their use in algorithmic trading systems, particularly under stressful situations like the current COVID-19 epidemic. As a result, taking into account the suggested model with Google's delayed explanatory factors, the important factors include 18 COVID-19 search volumes, gold returns, and the VIX index. Algorithmic trading methods based on COVID-induced public anxiety were used in the model (19). AEX, CAC 40, DAX 30, IBEX 35, and AEX were created for European stock market indexes, FTSE MIB. The findings revealed the potential of making a huge profit using then the basis of COVID-induced public anxiety, and 24 models have been suggested. It discovered how these systems work, provided good gross and net returns, a positive profit factor, and a% age of profit there have been 28 trading sessions that have resulted in a profit of more than 50%. The results of this research have a number of significant ramifications. On the one hand, the fact that public anxiety generated by COVID has a negative and substantial effect on the significance of this concern for the effective functioning of European stock markets of these markets' performance. As a result, the population's fear of the unknown must be managed by the government and the media must pay attention to the COVID-19 epidemic. This emphasizes the importance of the significance of finding the appropriate balance between the necessary concern from a health standpoint and point of view, as well as the possibility of a panic attack with severe consequences in the economy and, in particular, in stock markets. Furthermore, the data suggested that exceptional gains might be obtained, which are helpful for using algorithmic trading systems based on COVID-induced public anxiety investors, giving them the opportunity to profit from their investments. In the context of financial uncertainty resulting from the health crisis, 50 equity investments were made. Finally, we propose that further research paths based on the observed findings offer a far more in-depth knowledge of how illness fear affects stock prices from both a theoretical and methodological standpoint. Similarly, the outcomes achieved with the suggested algorithmic trading systems, significant research in the field is encouraged explanation of effective investing methods under adversity, such as a real-life financial crisis pandemic. Furthermore, although independent stock indexes were taken into account in this study, it would be interesting to take into account the public's fear of infectious diseases building diverse investment portfolios, which is number six on the list.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the Local Legislation and Institutional Requirements. Written informed consent for participation was not required for this study in accordance with the National Legislation and the Institutional Requirements.

AUTHOR CONTRIBUTIONS

YS: conceptualization, methodology, supervision, and writing – reviewing and editing. HL: conceptualization, software,

formal analysis, and writing – reviewing and editing. YC: conceptualization, methodology, and writing – original draft. All authors contributed to the article and approved the submitted version.

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Evaluating Global Inequality Using Decomposition Approach

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Given that there is no recent research on decomposition for global inequality, the aim of this study is to fill the gap in the literature by investigating global inequality with decomposition technique. The data of this study were compiled from the World Bank and decomposition by subgroups was conducted to evaluate the driving forces behind the evolution of inequality. Almost all the countries in the world were included in this study, and the study period spans from 2000 to 2017. The analysis was carried out in several stages to evaluate the issue of North–South divide, as well as the impacts of regional and income subgroups. There are several salient findings derived from this study. First, the results show that there was a gradual decline of international inequality within the study period. Second, there was still a large disparity between the developed and developing countries, and the inequality within the developing countries has aggravated further. Third, geographical location has exerted great impacts on global inequality and East Asia contributed about 40% to the overall decline in international inequality. Fourth, decline in inequality amongst the upper-middle-income countries also contributed substantially to the fall in international inequality. The results derived from this paper can provide pertinent information for the formulation of a comprehensive and coherent strategy in coordinating international efforts and managing inequality while promoting human development under the framework of the newly established Sustainable Development Goals.

Keywords: inequality, global, decomposition analysis, Theil index, North–South divide

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INTRODUCTION

Given that the Millennium Development Goals (MDGs) era has already come to a conclusion with the end of 2015, the General Assembly of the United Nations (UN) adopted the official document, *Transforming our world: the 2030 Agenda for Sustainable Development*, as the post-2015 global development agenda. This new universal agenda is made up of 17 new Sustainable Development Goals (SDGs) which are expected to stimulate global action over the next 15 years in areas of critical importance for humanity and the planet, namely, the economic, social and environmental

dimensions of sustainable development. It is expected that the implementation of this ambitious agenda would be achieved with the participation of all countries, all stakeholders and all people (United Nations, 2015).

Although equality is one of the core values of the UN' Millennium Declaration, the old MDGs only touch upon gender equality, and the targets of MDGs do not place enough emphasis on other forms of inequality (Melamed, 2012). However, with over 2 years of public consultation and engagement with civil society and other stakeholders around the world, the issue of inequality was finally integrated into the new agenda (United Nations, 2015) and was converted into the objective of the tenth goal, which is to "reduce inequality within and among countries." It can be expected that the adoption of the new agenda by the United Nations will surely lead to a surge in the demand for policy research studies in international inequality. The changes in UN's agenda call for a detailed research on the thorny issue of inequality for all the countries in the world so that policy implications can be drawn to assist countries in formulating inequality-alleviating policies.

Given the number of adverse impacts related to income inequality, a comprehensive study on inequality is justified to formulate policies that can alleviate inequality and ameliorate these adverse effects in the future. Country-specific regional disparity and income decomposition studies have been widely reported for developed (Karakoc, 2017; Kennedy et al., 2017; Kisiała and Suszyńska, 2017; Okabe and Kam, 2017; Bittencourt et al., 2019; Blanco and Ram, 2019) and developing (Choudhury and Chaterjee, 2016; Jang and Jeong, 2016; Paredes et al., 2016; Tian et al., 2016; Habibullah et al., 2017; Sehrawat and Giri, 2018; Calcagnini et al., 2019; Cevik and Correa-Caro, 2019; Le and Nguyen, 2019; Michálek and Výbošťok, 2019; Tchamyou et al., 2019) countries. However, to our knowledge there has been no recent study on the contributions of regional and income subgroups to international inequality for the world. This study aims to provide additional information concerning international income inequality for all the countries in the world so as to contribute to the literature in the post-MDGs era. This paper is divided into two parts. First, Theil-T and Theil-L indices are employed to provide an overview of the evolutionary patterns and trends of international inequality. Second, countries are divided into regional and income subgroups, and decomposition by subgroups is conducted to estimate the contributions of each of the subgroups and the inter-subgroup component to overall international inequality. The decomposition analysis can shed light on the underlying patterns of inequality, and quantify the level of the North–South divide. It can also reveal the relationship between inequality and different geographical and income subgroups, thereby pinpointing the crux of the problem of inequality.

The remainder of this paper is organized as follows. Section "Literature Review" reviews the relevant literature on international income inequality. Section "Methodology and Data" describes the methodology and data source. Section "Result and Discussion" conducts inequality measurement for all the countries and economies in the world; followed by computation of the contributions of different regional and income subgroups to overall inequality in an attempt to provide evidence on whether overall inequality can be mainly accounted for by the notorious North–South divide, or by the disparity within each of the different regional subgroup. Section "Conclusion" summarizes the research findings with policy implications.

LITERATURE REVIEW

Many researchers claim that inequality has increased considerably with globalization (Krugman and Venables, 1995; Alderson and Nielsen, 2002; Ha, 2012; Ezcurra and Rodríguez-Pose, 2013). With the deepening of globalization, international inequality has reached record levels. In 2015, the top one percent of the global population owns half of all the world's assets (Credit Suisse, 2015). This enormous level of disparity not only exerts damaging impacts on the progress of poverty reduction and economic growth, but also poses a threat to regional stability. Actually, the interlinkage and interdependence relationships created by increased globalization always carry the risk of contagion (Schmuckler, 2004). The countries are prone to social and economic instability in a globally interconnected economy as some scholar claimed that "the Southern predicament of instability and inequality does affect the economic and political well-being of the North itself" (Acharya, 1994).

It is well known that inequality can exert various adverse impacts on the progress of poverty reduction, the economic growth, and even social and political stability. Many researchers maintain that inequality exerts an adverse effect on poverty reduction (Rupasingha and Goetz, 2007; Zhuang, 2008; Fosu, 2009); while other studies claim that inequality has a negative impact on economic growth (Alesina and Rodrik, 1994; Persson and Tabellini, 1994; Alesina and Perotti, 1996; Deininger and Squire, 1998; Huang et al., 2009). Cheong and Wu (2015) found that inequality is positively correlated with the crime rate. Likewise, other researchers found that inequality can lead to different kinds of social dysfunction, such as mental illness, racism, social unrest and even political upheaval (Muller and Seligson, 1987; Alesina and Perotti, 1996; Wang and Hu, 1999; Acemoglu and Robinson, 2001; Wen, 2007; Dutt and Mitra, 2008; Wilkinson and Pickett, 2009; Knight, 2013).

Regarding the decomposition of international income inequality, there are typically three perspectives: North–South divide; income group; and regional effect. The global North–South divide has been studied for the service sector. Using a North–South growth model of endogenous industry location, it is found that trade integration leads to an increase in interregional real income inequality when the inter-sectoral knowledge spillovers from the manufacturing sectors are local (Fukuda, 2019). As for income group, Van Velthoven et al. (2019) used a panel data of many countries from 1975 to 2005 for analysis, and found that financial development, financial liberalization and banking crises are more influential than other factors in contributing to income redistribution. Based on a new panel data of Credit Suisse for 45 countries from 2000 to 2012, Islam and McGillivray (2019) found that the global

wealth inequality is negatively associated with cross-country economic growth. Adopting Granger Causality Test and System Generalized Method of Moments Model of 158 countries and 86 middle income countries from 1960 to 2014, Vo et al. (2019) found causality from economic growth to income inequality and vice versa for middle income countries. Studying the datasets of household income from 67 European, American and Asian countries for a wide span of years, Tao et al. (2019) found income distribution for low and middle income class populations follows an exponential law. As for regional effect, Rapacki and Prochniak (2019) found that during 1995 to 2015, central and eastern European (the CEE or EU11) countries' income levels converged to western European (the EU15) countries after obtaining the European Union memberships. Lee et al. (2019) applied the regression-based inequality decomposition approach to a panel data of 2006–2012, and found that financial development, urbanization, and globalization have a positive impact on income growth in China, yet only financial development has effect on promoting inclusive growth.

Although previous studies mentioned above provide important information on inequality, it is regrettable that there is no recent study focusing on international inequality and also the contributions of regional and income subgroups to global inequality. The aim of this study is to fill this gap in the literature by examining the relationship between inequality and these regional and income subgroups.

METHODOLOGY AND DATA

Milanovic (2005) concludes that inequality can be measured from two different perspectives. The first approach is based on an unweighted measure so that it can only show the inequality amongst the countries without taking their population into consideration, whereas the second approach emphasizes the inequality of the people, and hence population is incorporated into the formula. The second approach is better as it takes the population of a country into consideration.

It is worth noting that many inequality measurements are available; however, the most common ones are the Gini coefficient and the Theil-T/Theil-L indices because they satisfy the property of income-zero-homogeneity and the Pigou-Dalton condition (Bourguignon, 1979). Without delving too much into the technicalities, the income-zero-homogeneity refers to the value of the inequality measurement, which remains unchanged when there is a scale change of the whole income distribution (Cheong, 2012), whilst the Pigou–Dalton principle suggests that a transfer of income from a rich person to a poor person should result in a decline in the inequality indicator, so long as the transfer does not reverse the ranking of the two in the income distribution (Cheong, 2012). It is worth noting that the Theil-T and Theil-L indices can be decomposed completely into the components of the subgroups (Bourguignon, 1979; Shorrocks, 1980, 1984). However, the Gini coefficient cannot satisfy the property of additive decomposability, and it cannot be decomposed completely into the components of subgroups (Yao, 1999). Therefore, the inequality measurement results based on the Theil index can be employed in the decomposition by subgroups in analyzing the relationship between inequality and regional and income subgroups. Specifically, the Theil-T and Theil-L indices (Theil, 1967, 1972) are employed in this study.

Inequality Measurement

The formulae of the unweighted Theil-T and Theil-L, respectively, are:

$$Theil - T = \sum_i \frac{Y_i}{Y} ln \frac{\frac{Y_i}{Y}}{\frac{1}{R}} \quad (1)$$

$$Theil - L = \sum_i \frac{1}{R} ln \frac{\frac{1}{R}}{\frac{Y_i}{Y}} \quad (2)$$

where R is the total number of countries.

The formula of the population-weighted Theil-T is

$$Theil - T = \sum_i \frac{Y_i}{Y} ln \frac{\frac{Y_i}{Y}}{\frac{n_i}{N}} \quad (3)$$

And the formula of the population-weighted Theil-L is:

$$Theil - L = \sum_i \frac{n_i}{N} ln \frac{\frac{n_i}{N}}{\frac{Y_i}{Y}} \quad (4)$$

where Y is the total gross domestic product (GDP) of all the countries, Y_i is the GDP in country i, N is the total population in the world, and n_i is the population in country i.

Decomposition by Subgroups

The decomposition of inequality by subgroups can be employed to determine the contributions of the subgroups to overall international inequality (For details, please refer to Theil, 1967, 1972). Overall inequality is then decomposed into the inequality existing between these subgroups (the inter-subgroup component) and the weighted sum of the inequalities existing within these subgroups (the intra-subgroup component) (Bourguignon, 1979; Shorrocks, 1980, 1984).

Overall inequality, I, can be decomposed into the sum of the intra-subgroup component and inter-subgroup component.

$$I = \sum \mathrm{w_j} I_{intra,j} + I_{inter} \quad (5)$$

where W_j is the weight for the jth regional subgroup, $I_{intra,j}$ is the intra-subgroup inequality within regional subgroup j, and I_{inter} is the inter-subgroup component.

The weights of the Theil-T and Theil-L are not the same. Income weight should be used in Theil-T, whereas population weight should be used in Theil-L (Gustafsson and Li, 2002).

$$\text{The weight of Theil} - \text{T for regional subgroup } j = \frac{\mathrm{Y_j}}{\mathrm{Y}}$$

$$\text{The weight of Theil} - \text{L for regional subgroup } j = \frac{\mathrm{n_j}}{\mathrm{N}} \quad (6)$$

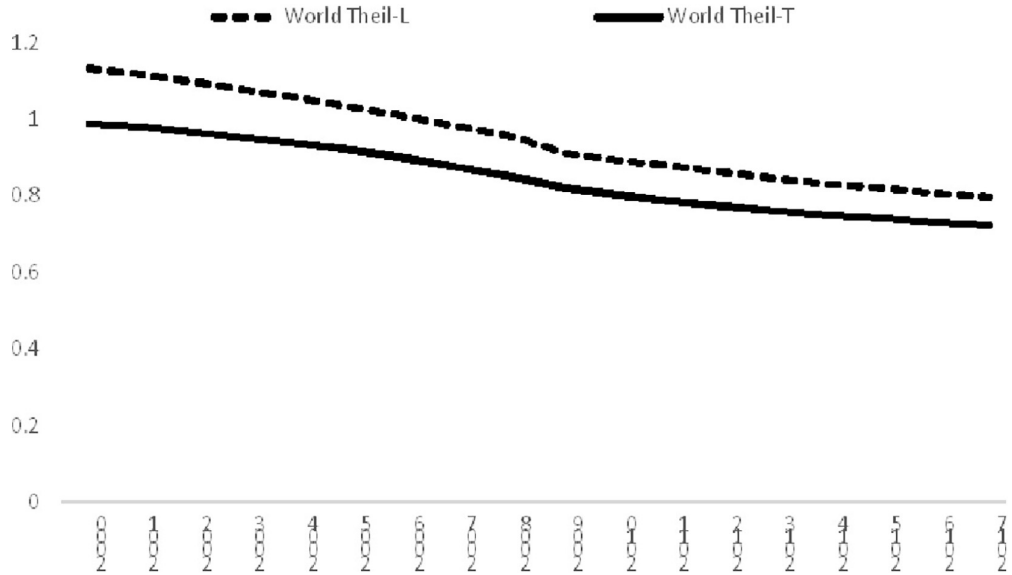

FIGURE 1 | Income inequality in the World, 2000–2017. Source: Authors' calculation.

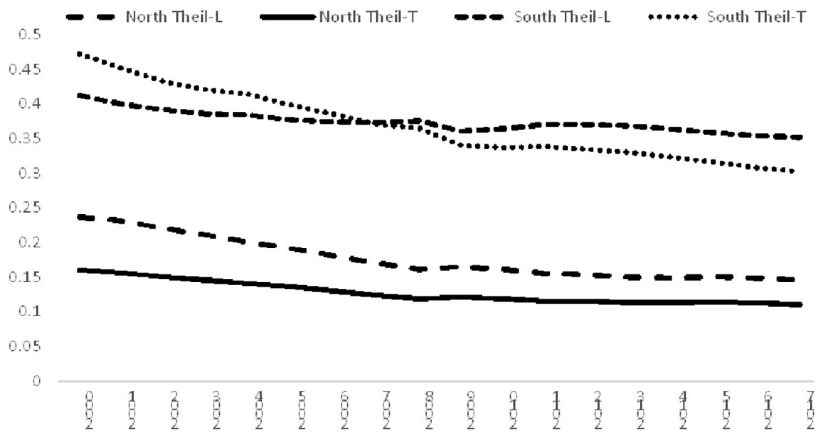

FIGURE 2 | Income inequality for the North and South, 2000–2017. Source: Authors' calculation.

where Y is the world GDP, Y_j is the regional GDP in subgroup j, N is the world population, n_i is the population in subgroup j. So W_j, the weight for the jth subgroup, is $\frac{Y_j}{Y}$ for Theil-T and $\frac{n_j}{N}$ for Theil-L where Y_j is the regional GDP in subgroup j and n_j is the population. The full dataset will be divided according to different schemes of subgroup, so the impacts of these subgroups can be observed in details.

Data

The data of all the countries employed in this study were compiled from the World Bank[1]. For each country, the data of GDP and population were collected for the computation of the Theil-L and Theil-T indices. It is worth noting that the same countries should be employed for the measurement of inequality for each year in the study period. The omission or addition of a country in a year may result in sudden change of the inequality measurement in that particular year, thereby providing misleading information on the evolution of inequality. Therefore, the countries employed in this study are the same across time. Almost all the countries listed in the World Bank World Development Indicators Database are included in this study, however, a few countries are excluded because of data unavailability. The study period spans from 2000 to 2017 for a total of 18 years.

There are several stages in this study. In the first stage, all the countries in the database were used to compute the Theil-L and Theil-T indices for the world. Then, in the second stage, the data were divided into two smaller data sets, namely, the North and South subgroups. The data were then divided into seven regional subgroups according to the regional classification

[1]https://data.worldbank.org/country

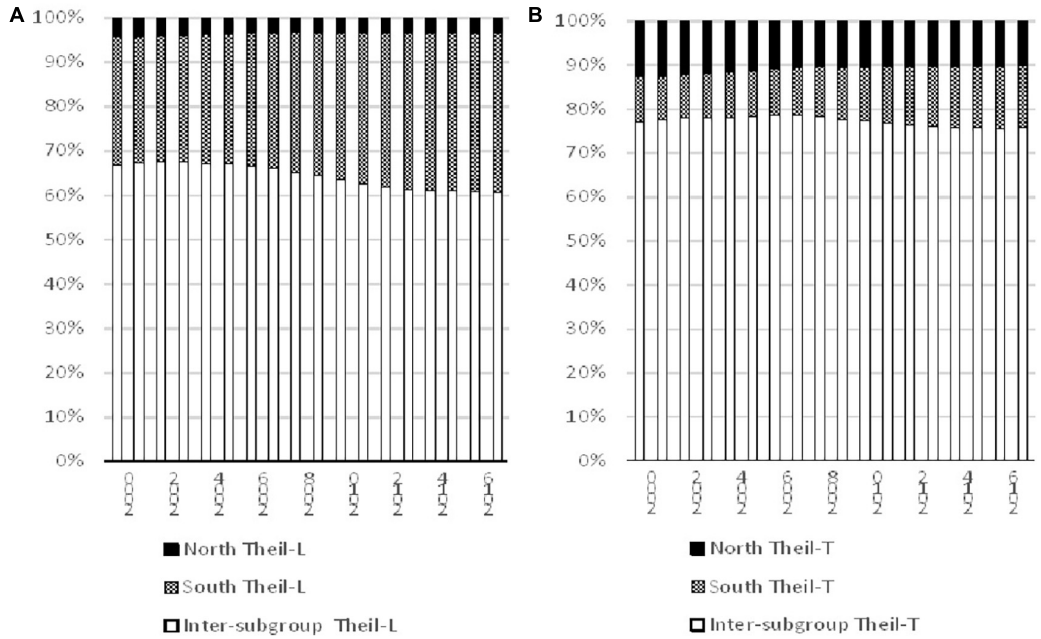

FIGURE 3 | Decomposition of inequality for the North and South, 2000–2017. Source: Authors' calculation.

proposed by the World Bank, namely, the East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, South Asia, and Sub-Saharan Africa in the third stage of the study. In the fourth stage, the countries are further classified into 17 regional subgroups so as to provide a detailed analysis on the relationship between international inequality and regional subgroups. Finally, in the fifth stage of this study, the data were separated into four income groups as defined by the World Bank, namely, low, lower-middle, upper-middle, and high income groups. This classification allows one to evaluate the inequality amongst these income groups and within them in great detail.

RESULTS AND DISCUSSION

The first analysis is based on the complete dataset. Section "North–South Divide" comprises the North (developed countries) dataset and the South (developing countries) dataset for analyses. Section "Regional Effect" provides a comparison of all datasets by regions and sub-regions, while Section "Income Group" provide the findings derived from the analyses which are based on income groups.

Figure 1 shows the income inequality of the world from 2000 to 2017. It can be observed that there was a gradual decline of international inequality within the study period. The Theil-L index dropped from 1.13 in 2000 to 0.80 in 2017, while the Theil-T index declined from 0.99 to 0.72 in that period. Although the values of the indices differ, both indices indicated that there was a 27–30 percent drop in international inequality. This is a very encouraging finding for pursuing the SDGs as it shows that the disparity amongst the countries has decreased across time.

North–South Divide

The evolution of inequalities within the North and South is shown in **Figure 2**. There are two salient findings: First, the inequalities within these two regions both declined steadily in the study period. However, it can be observed that the decline of the Theil-L index in the South is much slower than the Theil-T index in that region, thereby creating an intersection for the two indices in 2007.

Another interesting finding is that the inequality in the South was much higher than the North. Using Theil-L in inequality measurement, the ratio of the inequality of the South to the North was 1.74 in 2000, it then increased to 2.42 in 2017. However, the ratio of the inequality of the South to the North based on Theil-T index was 2.95 in the beginning of the study period, and it remained roughly the same, resulting in a ratio of 2.74 in 2017. The findings

TABLE 1 | Decomposition of change in inequality for the North and South, 2000–2017.

	2000	2000	2017	2017	Nominal change		Change (%)	
	Theil-T	Theil-L	Theil-T	Theil-L	Theil-T	Theil-L	Theil-T	Theil-L
World	0.99	1.13	0.72	0.80	−0.27	−0.34	−100.00	−100.00
Global North	0.13	0.05	0.07	0.03	−0.05	−0.02	−19.82	−6.73
Global South	0.10	0.33	0.10	0.29	0.00	−0.04	0.38	−11.67
Inter-subgroup	0.76	0.76	0.55	0.48	−0.21	−0.27	−80.56	−81.60

Source: Authors' calculation.

TABLE 2 | Income inequality for seven regional subgroups, 2000–2017.

	East Asia and Pacific	Europe and Central Asia	Latin America and Caribbean	Middle East and North Africa	North America	South Asia	Sub-Saharan Africa
				Theil-L			
2000	0.80	0.54	0.13	0.43	0.00	0.02	0.50
2001	0.77	0.53	0.13	0.41	0.00	0.02	0.50
2002	0.73	0.51	0.13	0.40	0.00	0.02	0.51
2003	0.70	0.49	0.13	0.43	0.00	0.02	0.51
2004	0.67	0.47	0.13	0.42	0.00	0.02	0.50
2005	0.63	0.45	0.13	0.41	0.00	0.02	0.50
2006	0.59	0.43	0.12	0.41	0.00	0.02	0.50
2007	0.55	0.41	0.12	0.40	0.00	0.02	0.50
2008	0.52	0.40	0.12	0.39	0.00	0.02	0.49
2009	0.47	0.40	0.12	0.36	0.00	0.02	0.48
2010	0.45	0.39	0.12	0.35	0.00	0.02	0.47
2011	0.43	0.39	0.12	0.38	0.00	0.02	0.46
2012	0.41	0.38	0.12	0.38	0.00	0.03	0.45
2013	0.39	0.37	0.12	0.38	0.00	0.03	0.44
2014	0.38	0.37	0.12	0.39	0.00	0.03	0.43
2015	0.36	0.38	0.11	0.40	0.00	0.03	0.42
2016	0.35	0.38	0.11	0.41	0.00	0.03	0.41
2017	0.34	0.37	0.11	0.41	0.00	0.03	0.39
				Theil-T			
2000	1.03	0.37	0.10	0.55	0.00	0.02	0.52
2001	0.99	0.36	0.10	0.53	0.00	0.02	0.51
2002	0.95	0.35	0.10	0.51	0.00	0.02	0.51
2003	0.91	0.34	0.10	0.53	0.00	0.02	0.50
2004	0.88	0.32	0.10	0.52	0.00	0.02	0.50
2005	0.83	0.31	0.10	0.51	0.00	0.02	0.50
2006	0.78	0.30	0.09	0.49	0.00	0.02	0.50
2007	0.73	0.29	0.09	0.47	0.00	0.02	0.50
2008	0.68	0.28	0.09	0.45	0.00	0.02	0.49
2009	0.62	0.28	0.09	0.41	0.00	0.02	0.47
2010	0.59	0.28	0.09	0.40	0.00	0.02	0.46
2011	0.55	0.28	0.09	0.42	0.00	0.02	0.46
2012	0.53	0.27	0.09	0.43	0.00	0.03	0.45
2013	0.50	0.27	0.09	0.43	0.00	0.03	0.44
2014	0.48	0.27	0.08	0.44	0.00	0.03	0.43
2015	0.46	0.27	0.08	0.45	0.00	0.03	0.42
2016	0.44	0.27	0.08	0.44	0.00	0.03	0.41
2017	0.42	0.27	0.08	0.43	0.00	0.03	0.40

Source: Authors' calculation.

suggest that inequality in the South is about 2.5 times higher than that in the North in 2017. This finding is alarming as it highlights the fact that the inequality amongst developing countries is significantly higher than the inequality amongst developed countries.

The decomposition results of the North and South are shown in **Figure 3**, while **Figure 3A** is based on Theil-L index and **Figure 3B** is based on Theil-T index. Similar conclusions can be reached even though the contribution percentage of the two measurements are not exactly the same. It is noteworthy that the largest contributor to global inequality is found to be the inter-subgroup component, followed by the inequality within the South and then the disparity within the North. The inter-subgroup component has declined steadily across time within the study period, however, it was still the largest contributor in 2017. The decline in percentage contribution was replaced by the rise in the inequality within the South. This finding is distributing as it indicates that although there was a decline of overall inequality in the world, there was still a large disparity between the developed and developing countries, and the inequality within the developing countries has aggravated further.

TABLE 3 | Decomposition of inequality for seven regional subgroups, 2000–2017.

				Theil-L				
Percent contribution	**East Asia and Pacific**	**Europe and Central Asia**	**Latin America and Caribbean**	**Middle East and North Africa**	**North America**	**South Asia**	**Sub-Saharan Africa**	**Inter-subgroup**
2000	23.67	6.68	0.96	1.88	0.00	0.36	4.54	61.91
2001	22.92	6.56	0.98	1.86	0.00	0.34	4.63	62.71
2002	22.14	6.37	0.99	1.84	0.00	0.36	4.87	63.44
2003	21.42	6.15	0.99	2.00	0.00	0.39	5.07	63.98
2004	20.83	5.92	1.04	2.02	0.00	0.42	5.19	64.58
2005	20.05	5.77	1.04	2.06	0.00	0.44	5.36	65.27
2006	19.16	5.62	1.05	2.09	0.00	0.48	5.56	66.03
2007	18.25	5.50	1.07	2.10	0.00	0.51	5.80	66.77
2008	17.40	5.38	1.09	2.12	0.00	0.51	5.93	67.56
2009	16.55	5.66	1.12	2.09	0.00	0.57	6.16	67.85
2010	16.17	5.64	1.19	2.12	0.00	0.66	6.28	67.96
2011	15.43	5.56	1.20	2.30	0.00	0.70	6.37	68.45
2012	14.98	5.49	1.20	2.40	0.00	0.74	6.46	68.73
2013	14.64	5.42	1.21	2.49	0.00	0.77	6.57	68.90
2014	14.20	5.49	1.19	2.60	0.00	0.82	6.62	69.08
2015	13.77	5.64	1.15	2.76	0.00	0.89	6.63	69.17
2016	13.37	5.68	1.12	2.87	0.00	0.96	6.59	69.41
2017	13.03	5.66	1.12	2.91	0.00	0.98	6.57	69.73
				Theil-T				
	East Asia and Pacific	**Europe and Central Asia**	**Latin America and Caribbean**	**Middle East and North Africa**	**North America**	**South Asia**	**Sub-Saharan Africa**	**Inter-subgroup**
2000	22.55	12.96	0.74	1.84	0.00	0.04	0.80	61.07
2001	22.13	12.92	0.74	1.78	0.00	0.04	0.82	61.57
2002	21.78	12.62	0.75	1.73	0.00	0.04	0.86	62.23
2003	21.48	12.18	0.74	1.86	0.00	0.05	0.88	62.82
2004	21.19	11.79	0.77	1.90	0.00	0.05	0.90	63.39
2005	20.76	11.47	0.76	1.91	0.00	0.05	0.94	64.10
2006	20.21	11.27	0.76	1.92	0.00	0.06	0.98	64.79
2007	19.78	11.14	0.77	1.88	0.00	0.07	1.04	65.33
2008	19.31	10.99	0.80	1.90	0.00	0.07	1.08	65.85
2009	18.75	11.24	0.82	1.85	0.00	0.08	1.13	66.14
2010	18.79	11.14	0.87	1.85	0.00	0.09	1.15	66.10
2011	18.20	11.07	0.88	1.99	0.00	0.10	1.18	66.57
2012	18.05	10.83	0.88	2.08	0.00	0.11	1.20	66.85
2013	17.97	10.62	0.89	2.15	0.00	0.12	1.23	67.02
2014	17.52	10.66	0.86	2.22	0.00	0.13	1.24	67.37
2015	17.12	10.82	0.80	2.30	0.00	0.14	1.22	67.60
2016	16.81	10.89	0.76	2.34	0.00	0.16	1.19	67.85
2017	16.56	10.85	0.75	2.30	0.00	0.17	1.17	68.21

Source: Authors' calculation.

Figure 1 shows that there was a decline of inequality within the study period, however, **Figure 3** indicates that the inequality within the South had increased in percentage contribution, therefore, it is difficult to evaluate the actual impacts of the South by the two figures. Therefore, following the practice employed by Cheong and Wu (2012), a decomposition of change is implemented to examine the contribution to the change in inequality within this period. By using decomposition on the change of inequality rather than the inequality index itself, the underlying determinant behind the change can be revealed in detail. The findings are shown in **Table 1**. It shows that the largest contributor of the change in overall inequality is the inter-subgroup component, thereby suggesting that the decline in the disparity between the North and South contributed to more than 80% of the overall decline in international inequality. For Theil-T index, the decline in the inequality within the North contributed about 20% to the overall decline, while it is 6.7% for the Theil-L index. However, the contribution of the South is

TABLE 4 | Decomposition of change in inequality for seven regional subgroups, 2000–2017.

	2000	2000	2017	2017	Nominal change		Change (%)	
	Theil-T	Theil-L	Theil-T	Theil-L	Theil-T	Theil-L	Theil-T	Theil-L
World	0.99	1.13	0.72	0.80	−0.27	−0.34	−100.00	−100.00
East Asia and Pacific	0.22	0.27	0.12	0.10	−0.10	−0.16	−38.90	−48.87
Europe and Central Asia	0.13	0.08	0.08	0.05	−0.05	−0.03	−18.71	−9.08
Latin America and Caribbean	0.01	0.01	0.01	0.01	0.00	0.00	−0.72	−0.59
Middle East and North Africa	0.02	0.02	0.02	0.02	0.00	0.00	−0.58	0.55
North America	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Asia	0.00	0.00	0.00	0.01	0.00	0.00	0.30	1.13
Sub-Saharan Africa	0.01	0.05	0.01	0.05	0.00	0.00	0.20	0.26
Inter-subgroup	0.60	0.70	0.49	0.56	−0.11	−0.15	−41.61	−43.39

Source: Authors' calculation.

quite mixed, it is 11.7% for Theil-L, but 0.38% for Theil-T which suggests that the inequality within the South had aggravated overall inequality further.

Regional Effect

In order to examine the impacts of regional subgroups in detail, the full dataset was divided into seven smaller regional datasets according to the regional classification proposed by the World Bank for assessing the trend and contribution of these regional subgroups. **Table 2** shows the inequality indices for these regions from 2000 to 2017, and it can be observed that the inequalities within most of the regions declined in that period, except for the region of South Asia. The Theil-L index of South Asia increased for 86%, while the Theil-T index increased for 62%. It is worth mentioning that there are two regional subgroups which had a significant drop in inequality, namely, East Asia and Pacific and Europe and Central Asia. The findings derived from the two indices are very similar: the inequality within East Asia and Pacific declined for about 60%, while that within Europe and Central Asia declined for about 30%. In the beginning of the study period, the East Asia and Pacific region had the highest level of inequality in the world, however, the disparity had been mitigated considerably and its Theil-L index was lower than many regions in 2017. The reduction in inequality within this region is phenomenal, and its impact on overall inequality will be investigated further by using decomposition techniques.

The results of decomposition of inequality by the seven regional subgroups are shown in **Table 3**. It shows that the contribution of the inter-subgroup component had increased from 2000 to 2017, thereby indicating that the disparity amongst the regions had gained in relative importance across time. Another interesting finding is that the contributions of East Asia and Pacific and Europe and Central Asia had both decreased, while the contributions of other regions had increased. The contribution of East Asia and Pacific had decreased from 24 to 13% for Theil-L and 23–17% for Theil-T, while the contribution of Europe and Central Asia had dropped for a small amount. However, it is worth mentioning that although the region of East Asia and Pacific had declined significantly, it remained to be the largest contributor to world inequality in 2017.

Given that the fall in inequality in the East Asia and Pacific region is so huge, decomposition of change in inequality was conducted to evaluate the contribution of all regional subgroups to the change in overall inequality. **Table 4** shows the results of the decomposition and it can be observed that the inter-subgroup component contributed more than 40% for the overall decline in inequality, while the contribution of the inequality within East Asia and Pacific region was 39% for Theil-T and 49% for Theil-L. This is an important finding as it shows that almost 50% (as measured by Theil-L index) of the drop in overall global inequality can be attributed to the fall in inequality within East Asia and Pacific. The decline in inequality within East Asia and Pacific not only mitigated disparity within this region, but also help reduce global inequality significantly. For the other regions, it can be observed that the contribution of Europe and Central Asia to the decline in global inequality was 19% for Theil-T and 9% for Theil-L, while the contribution of the other five regions were negligible.

Although the results derived from the decomposition by the seven regional subgroups suggests that the region of East Asia and Pacific and the region of Europe and Central Asia contributed significantly to the decline of inequality within the study period; however, the regional classification proposed by the World Bank is too broad and thus it cannot provide a clear picture to the regional impacts. Therefore, the dataset was further separately into 17 regions so that the analysis could be conducted in detail. However, in order to save space, only the results of Theil-T index will be provided, but it is worth mentioning that the results derived from the two indices are very similar. Interested readers may contact the authors for further details.

Table 5 shows the evolution of inequalities within the 17 regions. It is found that the inequalities in three regions had increased, namely, Central Asia, South Asia, and West Africa, while the inequalities in other regions had decreased. One important fact can be deduced for Central Asia, by comparing with the finding derived from **Table 3** which shows that the inequality in Europe and Central Asia had decreased, it implies that the drop in inequality within that region can be attributed to the decline in inequality within the regions of EU and Other EU, rather than Central Asia. Turning to another important region as shown in **Table 3**, namely, East Asia and Pacific, it

TABLE 5 | Income inequality (Theil-T) for 17 regional subgroups, 2000–2017.

	Theil-T								
	Caribbean	**Central Africa**	**Central Asia**	**East Africa**	**East Asia**	**EU28**	**Middle East**	**North Africa**	**North America**
2000	0.52	0.64	0.39	0.33	1.04	0.09	0.48	0.06	0.00
2001	0.54	0.65	0.43	0.32	1.00	0.08	0.47	0.06	0.00
2002	0.54	0.63	0.45	0.33	0.95	0.08	0.46	0.06	0.00
2003	0.54	0.61	0.47	0.35	0.90	0.07	0.49	0.06	0.00
2004	0.57	0.57	0.48	0.33	0.86	0.07	0.46	0.06	0.00
2005	0.53	0.56	0.49	0.32	0.81	0.07	0.45	0.07	0.00
2006	0.50	0.53	0.51	0.32	0.75	0.07	0.43	0.06	0.00
2007	0.48	0.53	0.51	0.33	0.68	0.06	0.40	0.06	0.00
2008	0.46	0.50	0.49	0.32	0.63	0.06	0.39	0.05	0.00
2009	0.45	0.49	0.47	0.31	0.55	0.06	0.36	0.05	0.00
2010	0.45	0.49	0.47	0.30	0.52	0.06	0.34	0.04	0.00
2011	0.44	0.49	0.48	0.28	0.48	0.06	0.36	0.04	0.00
2012	0.44	0.49	0.47	0.26	0.45	0.06	0.37	0.05	0.00
2013	0.43	0.47	0.46	0.26	0.42	0.06	0.38	0.05	0.00
2014	0.42	0.46	0.46	0.24	0.39	0.06	0.39	0.05	0.00
2015	0.42	0.45	0.44	0.24	0.37	0.06	0.41	0.05	0.00
2016	0.41	0.45	0.42	0.23	0.35	0.06	0.39	0.05	0.00
2017	0.40	0.44	0.42	0.23	0.33	0.06	0.39	0.05	0.00
	Central America	**Other EU**	**Pacific**	**South Africa**	**South America**	**South Asia**	**Southeast Asia**	**West Africa**	
2000	0.10	0.57	0.04	0.29	0.06	0.02	0.37	0.08	
2001	0.10	0.56	0.04	0.29	0.06	0.02	0.35	0.08	
2002	0.10	0.53	0.04	0.29	0.06	0.02	0.35	0.09	
2003	0.09	0.50	0.04	0.29	0.06	0.02	0.35	0.09	
2004	0.10	0.47	0.04	0.29	0.06	0.02	0.35	0.10	
2005	0.09	0.45	0.04	0.28	0.06	0.02	0.35	0.11	
2006	0.09	0.42	0.04	0.28	0.05	0.02	0.36	0.11	
2007	0.09	0.40	0.04	0.27	0.05	0.02	0.36	0.11	
2008	0.09	0.38	0.04	0.27	0.05	0.02	0.34	0.12	
2009	0.09	0.40	0.04	0.26	0.05	0.02	0.33	0.13	
2010	0.09	0.39	0.04	0.26	0.05	0.02	0.34	0.13	
2011	0.09	0.37	0.04	0.26	0.05	0.02	0.35	0.13	
2012	0.09	0.36	0.04	0.25	0.05	0.03	0.34	0.13	
2013	0.09	0.35	0.04	0.25	0.05	0.03	0.33	0.13	
2014	0.09	0.35	0.03	0.25	0.05	0.03	0.33	0.13	
2015	0.09	0.36	0.03	0.25	0.04	0.03	0.32	0.13	
2016	0.09	0.36	0.03	0.25	0.04	0.03	0.31	0.12	
2017	0.09	0.35	0.03	0.26	0.04	0.03	0.31	0.11	

Source: Authors' calculation.

can be observed that the Theil-T index within Pacific region had decreased from 0.04 to 0.03 in that period, while the Theil-T index of East Asia had declined from 1.04 to 0.33.

The decomposition results are shown in **Table 6**. There are several salient findings: First, the contribution of the inter-subgroup was 72.7% in 2000 and it increased to 79.9% in 2017. It shows that the disparity amongst the regions was huge, implying that geographical location had played a major role in global inequality. Second, based on **Table 6**, in 2000, the second largest contributor was the inequality within East Asia (18.2%), followed by Other EU (3.0%) and EU28 (2.6%). However, in 2017, the contribution of East Asia declined to the value of 10.4%, while the contribution of Other EU was 2.8%, and EU28 was 1.9%. It is worth noting that these three regions were still the largest contributors in 2017, however, their significance had decreased steadily in the study period.

In order to reveal the contribution to the change in inequality in greater detail, the decomposition of change of inequality was conducted, and the results are shown in **Table 7**. The inter-subgroup component contributed more than 50% to the overall decline in global inequality. Surprisingly, East Asia also contributed about 40% to this decline, thereby implying that an extremely large portion of reduction in global inequality can be attributed to inequality alleviation in East Asia alone. The

TABLE 6 | Decomposition of inequality (Theil-T) for 17 regional subgroups, 2000–2017.

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Caribbean	0.2	0.2	0.2	0.2	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Central Africa	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Central Asia	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
East Africa	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
East Asia	18.2	17.8	17.3	16.9	16.6	16.1	15.4	14.8	14.2	13.4	13.3	12.6	12.3	12.1	11.5	11.1	10.7	10.4
EU28	2.6	2.5	2.4	2.3	2.2	2.1	2.1	2.0	1.9	2.0	2.0	2.1	2.1	2.1	2.0	2.0	2.0	1.9
Middle East	1.3	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.3	1.4	1.5	1.5	1.6	1.6	1.6
North Africa	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
North America	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Central America	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Other EU	3.0	3.0	2.9	2.8	2.7	2.7	2.7	2.7	2.7	2.8	2.8	2.7	2.7	2.7	2.8	2.8	2.8	2.8
Pacific	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
South Africa	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
South America	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3
South Asia	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
Southeast Asia	0.9	0.9	0.9	0.9	1.0	1.0	1.1	1.1	1.1	1.2	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.5
West Africa	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1
Inter-subgroup	72.7	73.3	73.9	74.3	74.7	75.2	75.9	76.4	77.1	77.7	77.6	78.1	78.2	78.3	78.8	79.1	79.6	79.9

Source: Authors' calculation.

mitigation of disparity within East Asia not only alleviated the inequality within this region but also led to 40% of the drop in global inequality. This fact can be explained by the huge population living in East Asia and the rapid increase in income in this region within the study period. Turning to other regions, the EU28 subgroup contributed 4.3% for Theil-T and 1.3% for Theil-L, while Other EU subgroup contributed 3.7% for Theil-T and 2.7% for Theil-L.

Income Group

We have investigated the North–South divide, and the impacts of regional subgroup, now we analyses the impacts of income so as to offer a comprehensive analysis. The full dataset was separated into four smaller datasets based on classification of income as defined by the World Bank. The trend and evolution of inequalities within these income subgroups are shown in **Figure 4**. It can be observed that the inequalities within all the income subgroups had declined in the study period. In 2017, the Upper-middle-income subgroup had the lowest level of inequality, followed by the Low-income group. However, conclusions on the other income subgroups differ according to the Theil index used in calculation though the difference is very small. For Theil-L, High-income subgroup had the highest level of inequality, followed by lower-middle-income countries; while the Theil-T values for these two regions were nearly the same in 2017.

The results of decomposition by income subgroups are shown in **Figure 5**. **Figure 5A** is based on Theil-L index and **Figure 5B** is based on Theil-T index. It can be observed that both indices indicate that the contribution of the inter-subgroup had increased from 2000 to 2017, along with a decline in contribution of the inequality within the Upper-middle-income subgroup. The contribution of the inter-subgroup as measured by Theil-L index increased from 87% in 2000 to 93% in 2017, while the measurement based on Theil-T index changed from 90 to 93%. For Theil-T index in 2017, the second highest contributor to overall inequality is the High-income subgroup, followed by the Upper-middle-income subgroups, then the Lower-middle-income subgroups, while the Low-income subgroup contributed the least. However, the measurement based on Theil-L is a bit different and the second largest contributor is the Lower-middle-income subgroups though the ordering of the other subgroups were the same as those of Theil-T.

Table 8 shows the results of decomposition for the different income subgroups. It can be observed that the contribution of the inter-subgroup was 72% for Theil-L and 83% for Theil-T. The second largest contributor was the Upper-middle-income subgroup and its contribution was 11% for Theil-T and 22% for Theil-L. The total contribution of the inter-subgroup component and the Upper-middle-income subgroup was more than 94% no matter which index was employed in calculation. It is evident that the Upper-middle-income subgroup played a major role in global inequality and affected the evolution of disparity in the world considerably.

In summary, there are two major findings derived from the analyses. First, referring to the analysis based on decomposition by regional subgroup, except for the inter-subgroup component, the most important contributor was identified to be the East Asia region. Second, the results derived from decomposition by income subgroups shows that, except for the inter-subgroup component, the Upper-middle-income subgroup was the largest contributor. By combining the two findings, it is of interest to investigate if there is any country which belongs to both the subgroups of East Asia and Upper-middle-income at the same time. It is found that there is only one country which fits both classification, and it is identified to be China. It pinpoints the

TABLE 7 | Decomposition of change in inequality for 17 regional subgroups, 2000–2017.

	2000	2000	2017	2017	Nominal change		Change (%)	
	Theil-T	Theil-L	Theil-T	Theil-L	Theil-T	Theil-L	Theil-T	Theil-L
World	0.99	1.13	0.72	0.80	−0.27	−0.34	−100.00	−100.00
Caribbean	0.00	0.00	0.00	0.00	0.00	0.00	−0.26	−0.08
Central Africa	0.00	0.01	0.00	0.01	0.00	0.00	−0.03	0.03
Central Asia	0.00	0.00	0.00	0.00	0.00	0.00	0.28	0.13
East Africa	0.00	0.01	0.00	0.01	0.00	0.00	0.04	−0.35
East Asia	0.18	0.21	0.08	0.05	−0.10	−0.15	−39.52	−45.75
EU28	0.03	0.01	0.01	0.00	−0.01	−0.01	−4.31	−1.53
Middle East	0.01	0.01	0.01	0.01	0.00	0.00	−0.37	0.91
North Africa	0.00	0.00	0.00	0.00	0.00	0.00	0.00	−0.04
North America	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Central America	0.00	0.00	0.00	0.00	0.00	0.00	−0.15	−0.11
Other EU	0.03	0.02	0.02	0.01	−0.01	−0.01	−3.67	−2.67
Pacific	0.00	0.00	0.00	0.00	0.00	0.00	−0.03	−0.01
South Africa	0.00	0.01	0.00	0.01	0.00	0.00	0.00	−0.15
South America	0.00	0.00	0.00	0.00	0.00	0.00	−0.34	−0.44
South Asia	0.00	0.00	0.00	0.01	0.00	0.00	0.30	1.13
Southeast Asia	0.01	0.02	0.01	0.02	0.00	0.00	0.76	−1.22
West Africa	0.00	0.00	0.00	0.01	0.00	0.00	0.21	1.11
Inter-subgroup	0.72	0.81	0.58	0.64	−0.14	−0.17	−52.93	−50.98

Source: Authors' calculation.

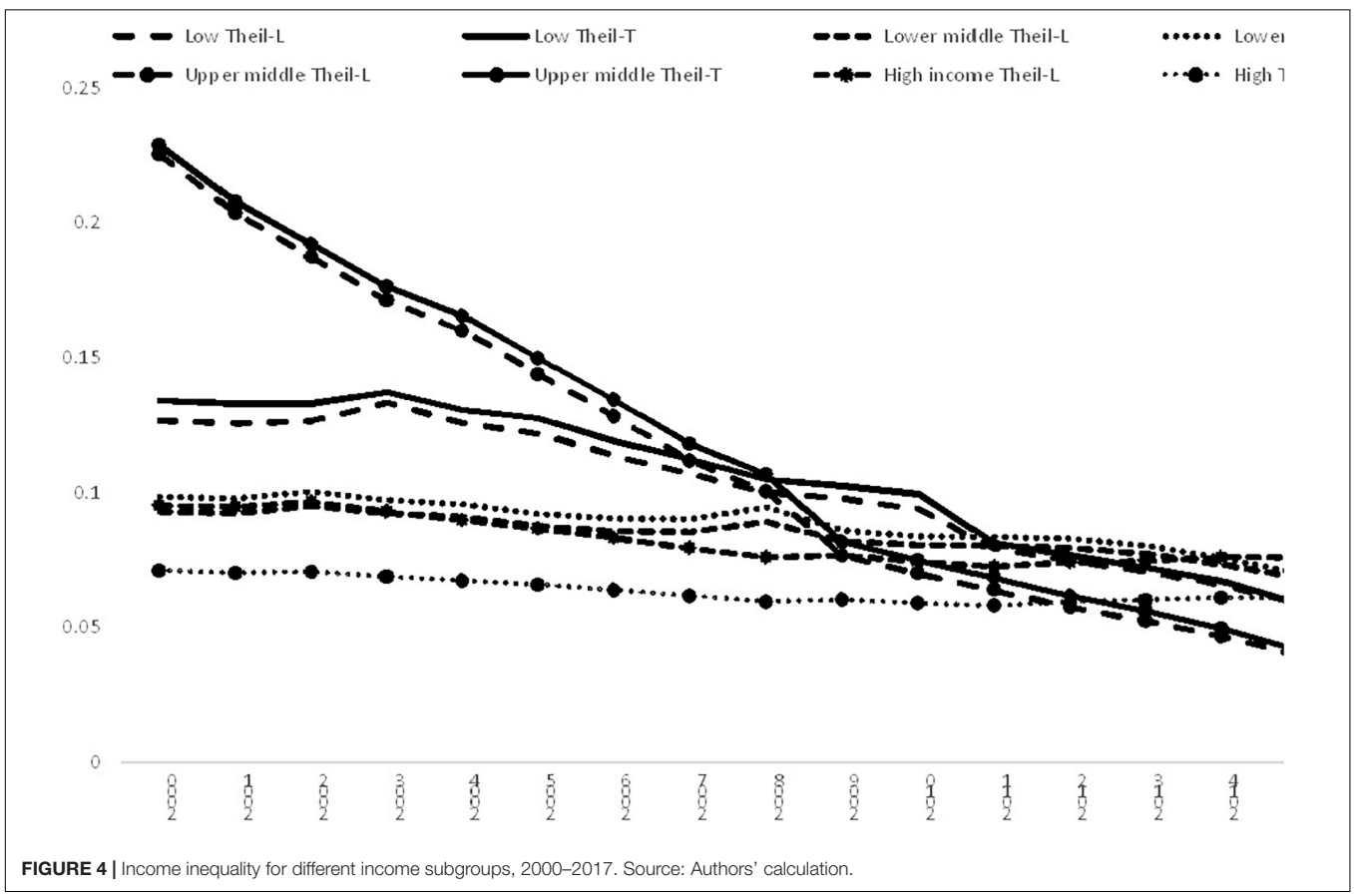

FIGURE 4 | Income inequality for different income subgroups, 2000–2017. Source: Authors' calculation.

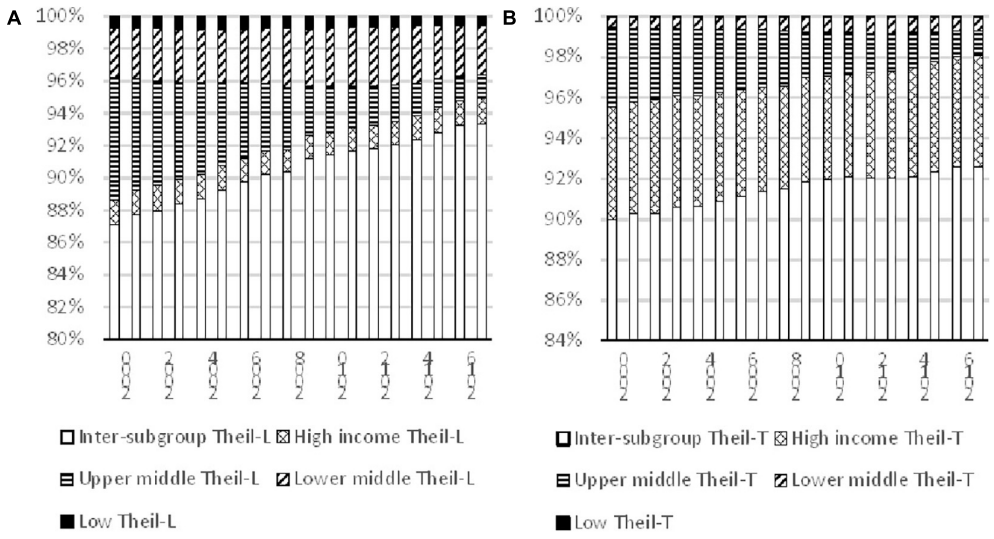

FIGURE 5 | Decomposition of inequality for different income subgroups, 2000–2017. Source: Authors' calculation.

TABLE 8 | Decomposition of change in inequality for different income subgroups, 2000–2017.

	2000	2000	2017	2017	Nominal change		Change (%)	
	Theil-T	Theil-L	Theil-T	Theil-L	Theil-T	Theil-L	Theil-T	Theil-L
World	0.99	1.13	0.72	0.80	−0.27	−0.34	−100.00	−100.00
Low income	0.00	0.01	0.00	0.00	0.00	0.00	−0.06	−0.95
Low middle income	0.00	0.04	0.01	0.02	0.00	−0.01	0.03	−3.18
Upper middle income	0.04	0.09	0.01	0.01	−0.03	−0.07	−11.26	−22.12
High income	0.06	0.02	0.04	0.01	−0.02	0.00	−5.84	−1.32
Inter-subgroup	0.89	0.99	0.67	0.74	−0.22	−0.24	−82.87	−72.43

Source: Authors' calculation.

importance of China in global inequality alleviation from 2000 to 2017. Economic development in China not only reduce disparity within East Asia and ameliorate inequality amongst the upper-middle-income countries, but also mitigate global inequality to a large extent.

CONCLUSION

The United Nations adopted the new Sustainable Development Goals (SDGs) and formulated a new global development agenda for all the countries in 2015. Given that the aim of the tenth goal of the SDGs is to reduce inequality within and among countries, therefore, it is of interest to investigate global inequality and its evolution across time. Inequality decomposition is a valuable tool for this strand of research as it can reveal the contribution of each component to global inequality in great detail. However, it is worth noting that there is no recent research on global international inequality and its decomposition, therefore the objective of this study is to fill the gap in the literature by investigating global inequality with decomposition technique.

The data of this study were compiled from the World Bank and decomposition by subgroups was conducted to evaluate the driving forces behind the evolution of inequality. Almost all the countries in the world were included in this study, and the study period spans from 2000 to 2017. The analysis was carried out in several stages to evaluate the issue of North–South divide, as well as the impacts of regional and income subgroups.

There are several salient findings derived from this study. The results show that there was a gradual decline of international inequality within the study period. This seems to be an encouraging finding, however, the decomposition results reveal that there are many worrisome issues behind the fall in international inequality. For the North–South divide, it is found that the inequality in the South was 2.5 times higher than that in the North in 2017. Another interesting finding is that the inequalities within these two regions both declined steadily in the study period. However, there was still a large disparity between the developed and developing countries, and the inequality within the developing countries has aggravated further.

Turning to the impacts of regional subgroups, three regions had increased in inequality, namely, Central Asia, South Asia, and West Africa, while the inequalities in other regions had decreased. The disparity amongst the regions was huge, implying

that geographical location had played a major role in global inequality. Although the contributions of the regions of East Asia, Other EU, and EU28 had declined significantly, they were still the largest contributor in 2017. East Asia contributed about 40% to the overall decline in international inequality.

The analysis based on income subgroups shows that the total contribution of the inter-subgroup component and the Upper-middle-income subgroup was more than 94%, thereby indicating that the Upper-middle-income subgroup played a major role in global inequality. It is notable that China is the only country which fits both classification of East Asia and Upper-middle-income. Therefore, the findings pinpoint the importance of China in global inequality alleviation. It is fair to comment that economic development in China not only reduced disparity within East Asia and ameliorated inequality amongst the upper-middle-income countries, but also mitigated global inequality to a large extent.

The findings have policy implications on the pre/post COVID times. Developing countries will be facing more challenges in tackling the pandemic due to lack of resources, thus our estimation results about North–South inequality will be even more severe in the aftermath of the pandemic. It is essential to assist poorer countries with more public goods, i.e., vaccines, to help low-income communities and those with poor sanitary environments, older people and those with a low awareness about the pandemic, so that more pertinent suggestions can be made for protecting the health of these subpopulations in the global south countries who are mostly affected by the pandemic.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: World Bank Database: https://databank.worldbank.org/source/world-development-indicators.

AUTHOR CONTRIBUTIONS

NM: formal analysis and writing – original draft. TC: data curation, visualization, and funding acquisition. JL: conceptualization and writing – review and editing. All authors contributed to the article and approved the submitted version.

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REVIEW
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COVID-19 Induced Economic Slowdown and Mental Health Issues

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The COVID-19 pandemic has pressed a pause button on global economic development, and induced significant mental health problems. In order to demonstrate the progressed relationship between the pandemic, economic slowdown, and mental health burden, we overviewed the global-level gross domestic product changes and mental problems variation since the outbreak of COVID-19, and reviewed comprehensively the specific sectors influenced by the pandemic, including international trade, worldwide travel, education system, healthcare system, and individual employment. We hope to provide timely evidence to help with the promotion of policymakers' effective strategies in mitigating economic losses induced by the pandemic; we suggest different governments or policy makers in different countries to share information and experience in dealing with COVID-19-induced economic slowdown and promote COVID-19 vaccine popularization plan to protect every individual worldwide against the coronavirus essentially; and we appeal international information share and collaboration to minimize stigmatization related to adverse mental consequences of COVID-19 and to increase mental health wellbeings of people all over the world.

Keywords: COVID-19, economic slowdown, mental health issues, GDP, international trade, unemployment, healthcare system, education system

INTRODUCTION

Since the first outbreak of COVID-19 caused by Severe Acute Respiratory Syndrome Coronavirus 2 at the end of 2019, the coronavirus has been keeping hovering all over the world and depressing the world populations' lives like a huge mist. With tens of thousands of individuals infected worldwide, medical emergency systems activated, and individuals' normal lives damaged, COVID-19 has pressed a pause button on economic development and induced significant mental health problems (Cross et al., 2020; Guan et al., 2020; Keogh-Brown et al., 2020; Sarkodie and Owusu, 2020). Right following outbreak, some researchers started paying attention to the impact of the pandemic on economic loss, and many others focused on investigating the influence on mental health burden. However, it is important to learn about the interrelation of the three on the process of establishing and implementing cost-effect strategies to fight against the pandemic and the plight related to COVID-19. Thus, in this review article, we aimed to present the connection between the

three – we overviewed the changes of global-level gross domestic product (GDP) and variation in mental problems since the outbreak of COVID-19, reviewed comprehensively the specific sectors influenced by the pandemic, and looked at the role that cultural and national differences might play in this relationship.

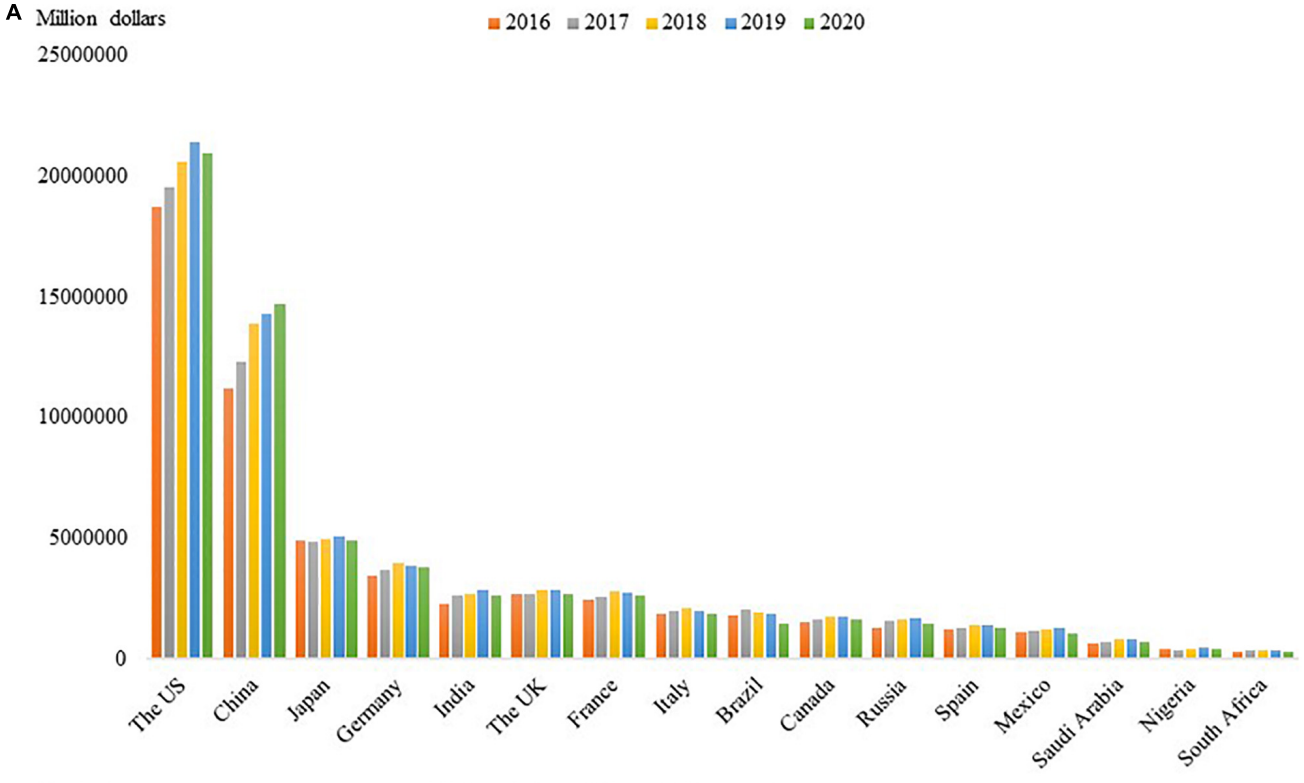
OVERVIEW OF THE EFFECT OF COVID-19 ON ECONOMIC AND MENTAL HEALTH

Economic activities are easily affected by various social factors, such as monetary policies (Balke et al., 2017; Zhang, 2019; An et al., 2021), credit shocks (Balke et al., 2021), and major public events like COVID-19 pandemic (Shang et al., 2021; Zhao Y. H. et al., 2021). The global economy encountered a serious recession in the second quarter of 2020. To demonstrate the economic changes more clearly, we summarized recent 5-year GDP changes in 16 countries worldwide and recent 3-year changes in GDP growth rates in major economies according to The World Bank (2021), International Monetary Fund (IMF) (2021), and Japanese Cabinet Office (National Accounts of Japan, 2021) (**Figures 1A–D**).

For most demonstrated countries, GDP increased between 2016 and 2019, whereas the increasing trend stopped abruptly in 2019 (**Figures 1A,B**). Negative GDP growth rates were encountered by most countries in 2020, except for China, based on World Bank and IMF estimations (**Figures 1C,D**). Although a causal relationship or direct association between economic shrink and COVID-19 cannot be concluded through the data, the pandemic played at least some roles in the economic crisis since 2019 and 2020 were the years when COVID-19 outbroke. In terms of a World Bank estimation, COVID-19 pandemic pushed between 88 million and 115 million people into extreme poverty in 2020. A research team from Italy used electricity market data to monitor real-time economic impact of the containment policies. According to their estimation, the 3 weeks of the most repressive outbreak period in Italy reduced the corresponding national GDP by about 30% (Fezzi and Fanghella, 2020). Another research suggested that the estimated GDP loss caused by COVID-19 related unemployment had reached 7.6 trillion, and the overall estimated GDP decline resulted from the pandemic was 3.4% (Arredondo et al., 2021). China, as the only country with no negative GDP growth, also encountered a huge challenge in the economic development due to COVID-19. For example, Zhao J. et al. (2021) estimated the economic burden of movement restriction policies (MRPs) and found that the first wave of COVID-19 in China resulted in a cost of 278 billion USD. Another Chinese team investigated different aspects of economic costs more carefully and concluded that although healthcare costs including inpatient care costs and other medicines costs account for a major part of economic burden in China, productivity losses which were mostly attributable to the effect of MRPs on people who did not have COVID-19 accounted for 99.8% of societal costs. Moreover, the control measures used to prevent COVID-19 spread have resulted in huge productivity losses which amounted to 2.7% (US$ 382.29 billion/US$ 14.14 trillion) of China's annual GDP (Jin et al., 2021).

Mental health changes related to COVID-19 outbreak have been investigated widely. Depression, anxiety, insomnia, acute stress or post-traumatic stress disorder (PTSD), suicide behaviors are common mental health problems which individuals suffer during COVID-19 (Bao et al., 2020; Meng et al., 2020; Shi et al., 2020; Wang et al., 2020; Xu et al., 2021). **Table 1** gives a summary of findings that explored variation of prevalence of mental health problems relative to the COVID-19 outbreak period. According to most studies, prevalence of mental problems was the highest during the outbreak period compared with both before outbreak and post outbreak (Barrea et al., 2020; Gallagher and Wetherell, 2020; Li X. Y. et al., 2020; McGinty et al., 2020; Salfi et al., 2020; van der Velden et al., 2020; Capuano et al., 2021; Creese et al., 2021; Jalal et al., 2021; Johnson et al., 2021; Martinez-de-Quel et al., 2021; Megalakaki et al., 2021; Mei et al., 2021; Pieh et al., 2021; Ramiz et al., 2021; Yang et al., 2021). One study from Argentine reported an even higher prevalence of sleep problems and moderate to severe depressive symptoms post outbreak (32.1 and 47.8%, respectively) compared with that during outbreak (23.1 and 24.3%, respectively). Shi et al. (2021a) from China reported a higher persistent prevalence of depression and insomnia (33.6 and 35.3% vs. 30 and 29.8%, respectively) from first wave of pandemic to the aftermath of the outbreak (Shi et al., 2021a). These reports suggested the huge adverse effect of COVID-19 outbreak on mental health conditions (Badellino et al., 2021).

The economic crisis triggered by COVID-19 pandemic can be considered as one possibility accounting for COVID-19-related mental health problems (McInerney et al., 2013). It is generally recognized that economic crisis has a vicious impact on mental health (Sun et al., 2020). One-month prevalence of major depression was found to be 8.2% in the Greek population in 2011, the year that the country was in the throes of economic collapse, which was 2.6 times compared to the prevalence rate in 2008 (Economou et al., 2013). Since 2007, nearly all European countries have encountered the economic shock and the situation was the worst in Spain. Compared with the pre-crisis period of 2006, the proportion of patients with mood, anxiety, somatoform, and alcohol-related disorders had a substantial and significant increase during the economic crisis period. Families experiencing unemployment and mortgage payment difficulties suffered the most (Gili et al., 2013). The October 2008 stock market crash in the United States had put a large number of older adults into depressive status and the adverse effect of sudden economic shock was the largest among individuals with high levels of stock holding prior to the crash. In the case of COVID-19, a sharp decline or negative growth of GDP is a macroeconomic reflection of the pandemic's impact on per capita income (Capello and Caragliu, 2021). Individuals encountered job loss and/or income contraction due to the pandemic, which would contribute to their worse life quality and subjective wellbeing (Rasul et al., 2021). Therefore, in this review, we propose a progressive relationship between COVID-19, economic slowdown, and mental health problems (**Figure 2**). That is, we believe that the economic slowdown induced by



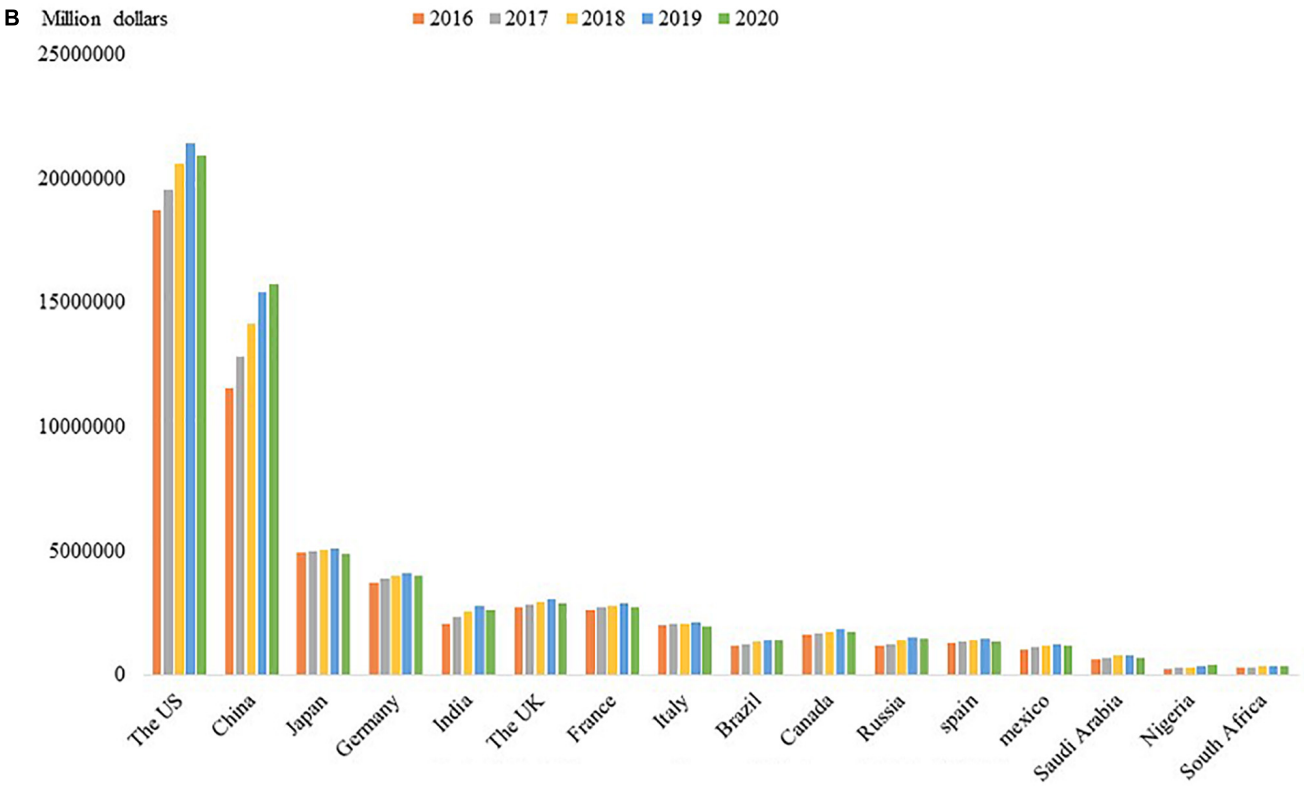


FIGURE 1 | (Continued)

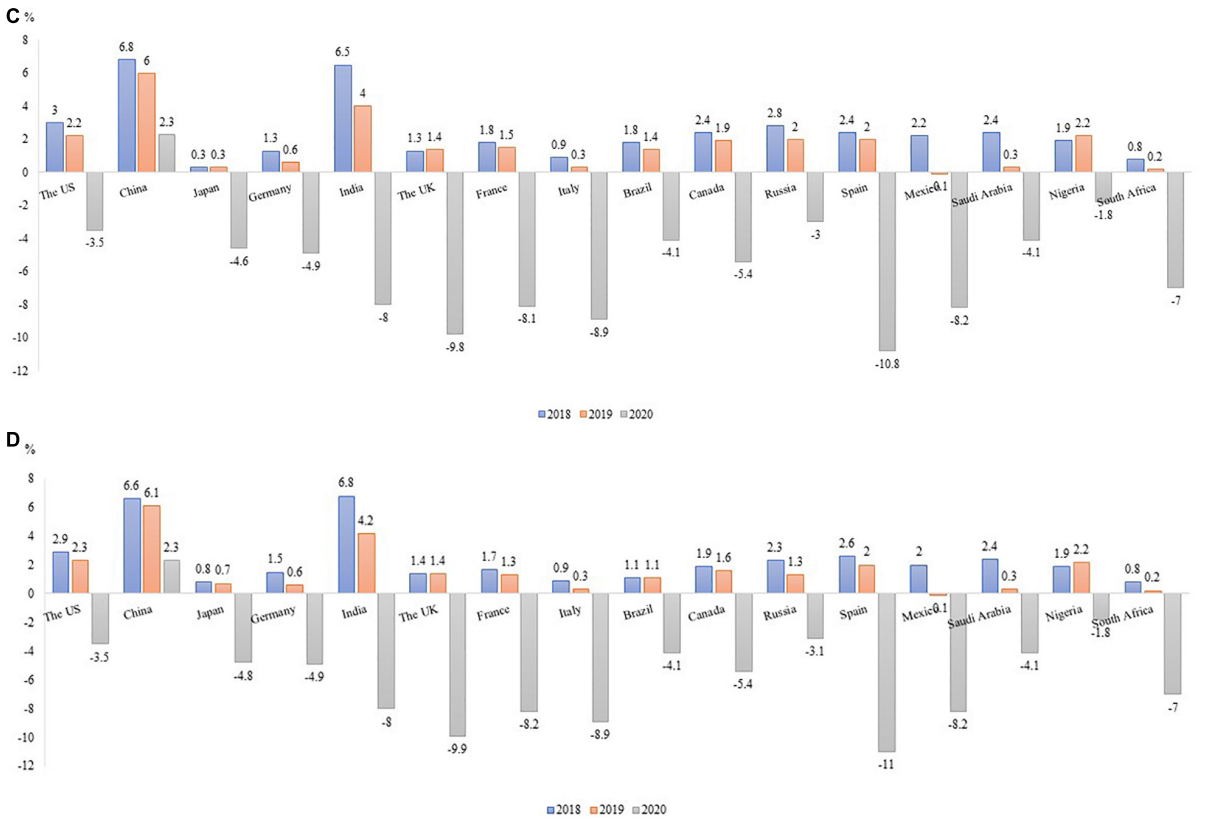


FIGURE 1 | (A) GDP Changes from 2016 to 2020 (World Bank). Based on data from the World Bank database, the change in GDP of the world's major economies from 2016 to 2020 is calculated in current US dollars (August 21, 2021). The World Bank database lacks the GDP data of Japan in 2020. The data here comes from the Statistics of the Japanese Cabinet Office and is converted to current US dollars (Japanese Cabinet Office: https://www.esri.cao.go.jp/jp/sna/menu.html). **(B)** GDP Changes from 2016 to 2020 (IMF). Based on data from International Monetary Fund (IMF) database, the change in GDP of the world's major economies from 2016 to 2020 is calculated in current US dollars (September 8, 2021). The IMF database lacks 2020 GDP data for China, India, Russia and Nigeria, which are derived from the World Bank database and converted to current US dollars. **(C)** Changes in annual GDP growth (%) rates in major economies (World Bank). Based on data from the World Bank database. The World Bank database lacks the GDP data of Japan in 2020. The data here comes from the Statistics of the Japanese Cabinet Office (Japanese Cabinet Office: https://www.esri.cao.go.jp/jp/sna/menu.html). **(D)** Changes in annual GDP growth (%) rates in major economies (IMF).

COVID-19 pandemic is interrelated with many negative mental health consequences during this period. In the next part of this review, we will look into more details about the interrelationship between the three.

SPECIFIC SECTORS IMPACTED BY COVID-19 AND RELATED MENTAL PROBLEMS

In the following session, we list specific economic impacts of COVID-19 pandemic, including international trade, travel, education system, healthcare system, and individual employment, as well as mental health problems related to these economic impacts.

International Trade Decline and Associated Mental Health Problems

COVID-19 created an international trade decline through reducing both demand and supply. For example, China is one of the biggest countries worldwide exporting manufactured goods, whereas, export prohibitions and restrictions introduced by over 80 countries and customs territory due to the pandemic blocked the just-in-time manufacturing between China and the other areas in the world and drove a huge chock on manufacturing market (Barlow et al., 2021). Estimated contraction of total global merchandise trade was by 9.2% in 2020, with a hard hit on supplies of pharmaceuticals and medical equipment, leading to detrimental consequences for physical and mental health (Barlow et al., 2021). Many global trades nowadays focus not on price the most but on relation the most. In the relation-driven agent-based global trade model, the role of relational factors including trust, familiarity, reputation, trade history and conflicts in countries' trade behavior is very important. Healthy global trade relationship with close international interaction and communication has been suggested to improve the food and nutrition security of countries in Africa, Asia and Latin America and successively promote a healthier and more balanced diet (Ge et al., 2021). COVID-19 has a negative effect on the balance of the relation-driven global trade and the limited

TABLE 1 | Summary of findings investigating prevalence of mental health problems relative to the COVID-19 outbreak period.

References	Site	Participants	Outcomes	Prevalence-Before	Prevalence-During	Prevalence-Post
Badellino et al. (2021)	Argentine	general population	bad sleep quality	/	23.1% (459/1985)	32.1% (912/2839)
Barrea et al. (2020)	Italy	general population	poor sleep quality	50.4% (61/121)	/	81% (98/121)
			moderate to severe depression	/	24.3% (482/1985)	47.8% (1357/2839)
Capuano et al. (2021)	Italy	patients with physical disorder	depression	11.90% (8/67)	11.90% (8/67)	/
			anxiety	11.90% (8/67)	16.40% (11/67)	/
Creese et al. (2021)	United Kingdom	older adults (age M 50)	mild depression	13.2% (392/3281)	19% (634/3281)	/
			moderate-to-severe depression	4.1% (124/3281)	5.6% (185/3281)	/
			mild anxiety	9.3% (276/3281)	12.6% (415/3281)	/
			moderate-to-severe anxiety	2.2% (66/3281)	2.7% (89/3281)	/
Gallagher and Wetherell (2020)	United Kingdom	caregivers	depression	16.7% (225/1349)	21.6% (291/1349)	/
		non-caregivers	depression	12.1% (748/6178)	17.9% (1106/6178)	/
Jalal et al. (2021)	Saudi Arabia	students studying bachelor's degree programs	bad sleep quality	70.1% (440/628)	79.9% (502/628)	/
Johnson et al. (2021)	Norway	general population	depression	/	23% (659/2868)	16.8% (250/1489)
			anxiety	/	23.3% (667/2868)	13.8% (205/1489)
Li X. Y. et al. (2020)	Wuhan, China	anesthesiologists and operating room medical staffs	depression	/	41.6% (82/197)	13.2% (26/197)
			anxiety	/	43.1% (85/197)	15.7% (31/197)
Martinez-de-Quel et al. (2021)	Spain	general population	poor sleep quality	63.40% (102/161)	75.2% (121/161)	
McGinty et al. (2020)	United States	general population	stress	3.9% (991/25417)	13.6% (199/1468)	/
Mei et al. (2021)	China	pregnant	mild depression	20.5% (482/2352)	36.2% (192/531)	/
			moderate depression	0.6% (13/2352)	10.4% (55/531)	/
			mild anxiety	24.7% (580/2352)	26.9% (143/531)	/
			moderate anxiety	3.1% (73/2352)	4.5% (24/531)	/
Megalakaki et al. (2021)	France	general population	COVID-19 peritraumatic distress	/	35.5% (398/1123)	17.2% (40/232)
Pieh et al. (2021)	Austria	general population	moderate	/	14.6% (64/437)	15.6% (68/437)
			moderate to severe depression	/	18.3% (80/437)	19.7% (86/437)
			moderate anxiety	/	16.5% (72/437)	15.6% (68/437)
Ramiz et al. (2021)	France	general population	depression	27% (278/5356)	27.6% (341/1237)	/
			anxiety	17.3% (180/5476)	20.1% (248/1237)	/
Salfi et al. (2020)	Italy	woman	moderate to severe insomnia	/	13.12% (254/2701)	11.63% (314/2701)
		man		/	9.37% (253/2701)	12.02% (324/2701)
		woman	depression	/	7.20% (194/2701)	6.50% (175/2701)
		man		/	4.47% (120/2701)	5.71% (154/2701)
Shi et al. (2021a)	China	general population	depression	/	30% (3151/10492)	33.6% (3528/10492)
			anxiety	/	35.2% (3693/10492)	32.5% (3415/10492)
			insomnia	/	29.8% (3127/10492)	35.3% (3701/10492)
			any mental health symptoms	/	46.4% (4865/10492)	45.1% (4733/10492)
van der Velden et al. (2020)	Netherlands	general population	anxiety and depression	7.2% (239/3983)	7.8% (257/2980)	/
Yang et al. (2021)	Hangzhou	general population	depression	13.7% (431/4144)	20.2% (636/3153)	/

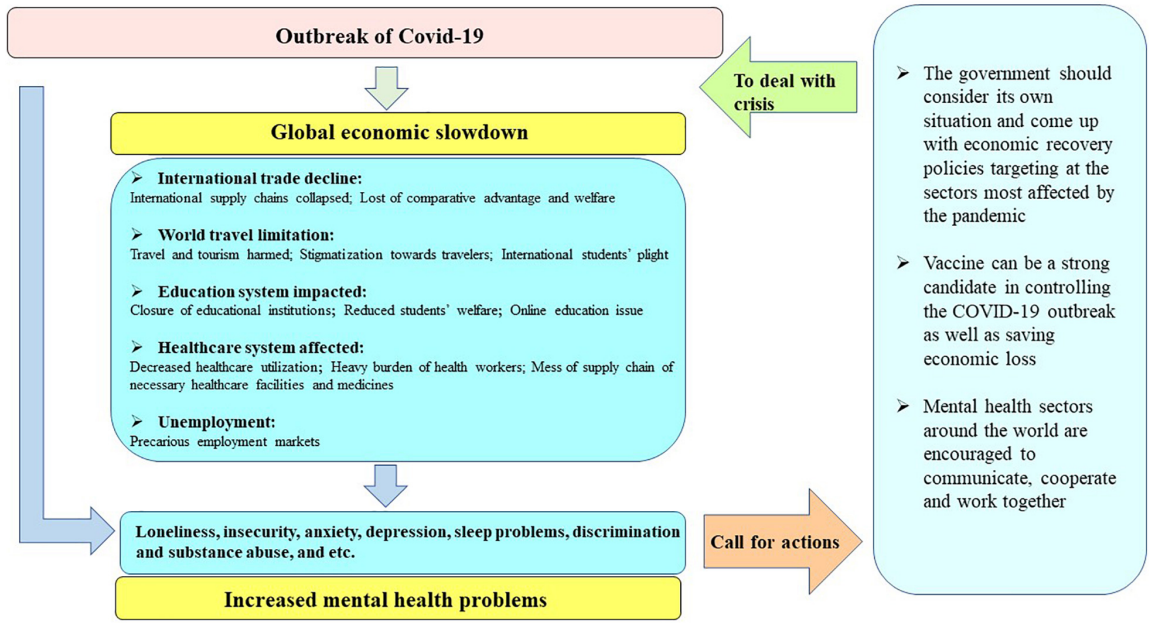


FIGURE 2 | Summary flow chart.

communication among countries will lead to a huge alternation of individual physical and mental wellbeing eventually.

Besides, as for individuals living in border areas and those who rely on international supply chains to earn lives, the collapse of many international supply chains is like a bolt from the blue. The UN World Food Programme estimated that by the end of 2020, the number of people suffering from severe hunger will almost double due to the pandemic. Theories of international trade propose that foreign trade can lead to a society's ultimate gain in comparative advantage and welfare, which is significant for the social members' mental health (Lin et al., 2020). The team of Lin et al. (2020) applied a fixed effects regression model to explore the prevalence of depressive disorders as a function of international trade and found that a 100% increase in the value of international trade indicated a 0.09%-point decrease in the prevalence of depressive disorders, and vice versa. Similarly, import competition which disproportionately brought wealth shock on industry labors could have a large negative impact on individual mental health, which can even have negative spillovers to other family members' mental wellbeing (Colantone et al., 2019). Hence, the affected international trade by COVID-19 pandemic is not only an unfortune for global economic growth, but also for individual mental wellbeing.

Worldwide Travel Limitation and Potential Mental Health Problems

The World Travel and Tourism Council warned that the outbreak of COVID-19 might put 50 million jobs in the global travel and tourism sector into risk, leaving the tourism sector as one of the hardest-hit due to the pandemic (Ataguba, 2020; Nicola et al., 2020; Siddiquei and Khan, 2020; Rasul et al., 2021). In South Asia, the travel and tourism sector created about 50 million jobs in 2018, which contributed to a significant amount of national GDP. However, the outbreak of COVID-19 and the mitigation measure drove demands in tourism and travel into collapse all of a sudden. Chinese visitors received by Vietnam dropped from about 1.45 million in the first quarter of 2019 by 644,000 in January of 2020, which resulted in a huge economic loss (Nicola et al., 2020). On March 12, 2020, the Nepal government canceled all Everest expeditions slated for the spring season, thus, expenses including US$4 million annual collections in royalties from Everest climbing permits and US$40,000–90,000 other expenses were in loss (Rasul et al., 2021). In the trekking sector alone in South Asia, approximately 20,000 tour guides would lose their jobs due to the tourism demand contraction, up to 60,000 employees in the hospitality sector in major capitals were affected, and 40–50 million job cuts were imminent from big hotels, travel agencies and tour operators in India (Rasul et al., 2021). Implement of travel ban compelled the cancelation of a number of airlines, such as Lufthansa and Cathay Pacific, Chinese airlines, Singapore Airlines, etc. Employees in these companies were asked to stay at home and there might be a possibility of layoffs due to the reduced number of flights (Siddiquei and Khan, 2020).

Travel should have been a wholesome activity for most people. On the trip, travelers from different countries and regions can exchange their unique cultures and happiness with each other through active communication and interaction. However, as governments across countries advised their citizens to avoid unnecessary travel, subjective stigmatization toward travelers was developed, especially toward those belonging to Coronavirus-prone countries. This feeling could be a culprit for further mental health problems among the population. For individuals who have traveled in the epidemic area before the outbreak,

according to research, they were more likely to suffer from internalized stigmatization associated with the travel experiences. They may develop internal fear of discrimination and exclusion by other members of the community and further develop negative emotions and cognitions such as self-deprecation, feeling dirty, and self-blame, and in more severe cases, symptoms of anxiety and depression will make the traveler to suffer a lot (Li J. et al., 2020).

A special group of "travelers" is the team of international students who travel to another country with different cultures and local customs and practices, and who will return to their own countries after the learning experience. With the impact of COVID-19, many international students had to return to their home country or region and were unable to go back to school for classes. These students faced a wide range of transitional events and ongoing stressors as they had to adapt to new academic environments and demands in order to keep up with their studies. There are also international students unable to return to their families and friends in the home country due to travel restrictions and extremely high travel expenses. They are away from their central social support systems and worried about their family members' conditions, all of which can be great challenges during the special period and hence affect their mental health (Lai et al., 2020). An investigation showed that 84.7% of the studied international students reported moderate-to-high perceived stress since outbreak of the pandemic, 12.1% had moderate-to-severe symptoms of anxiety and depression, and 17.1% had moderate-to-severe symptoms of insomnia (Lai et al., 2020). Feeling lonely is the main concern for international students who undergo a self-isolation process. Economic shock brought by the pandemic put international students' lives in the host country in more difficulty since the price of commodities could be higher than usual. Students who are about to graduate could feel more stressed because of the unforeseen future including unknown graduate dates. Research showed that international students facing job-hunting, severe economic pressure, and poor self-rated health status had higher levels of stress, anxiety, depression, and PTSD symptoms (Song et al., 2021; Wilczewski et al., 2021). Many international Chinese students also experience discrimination and isolation in some countries due to being deemed as potential coronavirus carriers, which can lead to mental problems such as denial, stress, anxiety, and fear (Zhai and Du, 2020). Fortunately, social support was shown to be a protective factor for mental health wellbeing. More social interaction and communication will help keep individuals' positive emotions (Li J. et al., 2020).

Education System by COVID-19 and Associated Mental Health Problems

All levels of the education system, from preschool to tertiary education, has been affected by the outbreak of pandemic. Over 100 countries have imposed a nationwide closure of educational facilities, although different countries implemented various policies with some countries announcing complete closure like in Germany and Italy and other countries announcing targeted closure like in the United Kingdom. In the case of Australia, the higher education sector expected the revenue loss to be AUS$3–4.6 billion in the academic year 2019–2020. Besides, the number of international student enrollments in the United States was expected to reduce by at least a quarter, with a huge loss of income from the higher education sector (Thepphakorn et al., 2021). According to the estimation by United Nations Educational Scientific and Cultural Organization (UNESCO), up to 900 million learners were affected by the closure of educational institutions (Nicola et al., 2020). Many parents have to stay at home from work with their children out of school. The United States federal government put school closures as an important strategy for Pandemic Influenza Mitigation. Although effective in reducing virus transmission, previous literature showed that closing schools in the United States for 4 weeks could cost between $10 and $47 billion which accounted for 0.1–0.3% of GDP as well as a reduction of 6 to 19% in key health care personnel (Lempel et al., 2009). Similarly, in the United Kingdom, researchers have found that closing all schools for 4 weeks would cost between 0.1 and 0.4% of GDP and about 16% of the workforce would take absenteeism since they were the main caregiver of dependent children (Sadique et al., 2008). Schools were no longer able to provide free school meals for children which had a significant impact on childcare costs for families with young children, especially for low-income families. This added new household expenditure that could otherwise be economized (Alvi and Gupta, 2020). In addition, online learning has become a new fashion of education ushered by the pandemic. Just like a space of classroom as the necessity for face-to-face education, digital technologies and electronic devices are the new necessities for online education. This new normal of education strategy is always fueled by commercialism and the reigning market ideology, compared to the traditional education system. In fact, not all students were able to afford this internet-based economic activity (Pacheco, 2020; Muthuprasad et al., 2021; Rasul et al., 2021). What's more, school closures as a short-term emergency measure to contain pandemic may lead to students' increased dropout possibility from school in the long-term. Based on UNESCO estimation, about 0.32 billion students in India had been affected by school closures since the outbreak of COVID-19, many of whom will be pushed into the labor market without adequate education background (Alvi and Gupta, 2020).

A remote online learning strategy may cause a series of emotional issues for the learners. Unpreparedness to learn an online course, working with "unknown others," unfamiliarity with information technology are all potential risk factors contributing to individuals' anxiety. In the case of COVID-19, some specific anxious factors are the sudden absence of a scheduled university environment, an unprecedented shift from school to home environment, disrupted learning and classroom routines, increased academic workload, uncertainty about academic progress (Zhao T. et al., 2021). As students encounter a limited opportunity of communication with peers and teachers, they will suffer from the lack of socialization and the stressed feeling of having fallen academically behind other peers. Without proper intervention, these negative feelings can eventually give rise to comorbidities such as depressive symptoms (Li H. et al., 2020).

Hasan and Bao (2020) evaluated the psychological effects of COVID-19 "e-learning crack-up" with a sample of 400 higher education students in Bangladesh and concluded that fear of academic year loss was a great predictor for students' psychological distress during the pandemic. Extreme feelings of seclusion, helplessness, panic attacks, and comorbid sleep problems have been often reported by student respondents during school closures due to the pandemic (Li H. et al., 2020; Shih et al., 2021; Tzafilkou et al., 2021). What's worse is that study suggested lower educational attainment due to school closure was associated with lifelong mental health problems including but not limited to depression and schizophrenia (Yoshikawa et al., 2020). The mental health of university students was also being affected by abnormality of daily routine, such as lack of daily leisure and social interaction and loss of academic routines, which included classes and clinical sessions. In addition, students who were presented with history of mental illness and chronic medical illness should also be given additional attention as they are prone to develop mental health complications, such as depression and anxiety. A protective factor of utmost important was greater degree of social support received from friends and family members. In addition to the mental health impact, the sudden alteration in the conduct of education in university also lowered the psychological and social aspects of quality of life among university students (Leong Bin Abdullah et al., 2021; Woon et al., 2021a).

Healthcare System Impacted by COVID-19 and Potential Mental Health Problems

The COVID-19 wreak havocs on the healthcare system. A stable and functional health system should consist of skilled healthcare personnel, well-maintained facilities and infrastructural frameworks, adequate available personal protective equipment (PPE) and medicines, and more importantly, an effective communication with patients (Okereke et al., 2021). The pandemic made a mess of supply chain of necessary healthcare facilities and medicines. Active pharmaceutical ingredients are imported largely from China, India, and the EU, and China is also the biggest exporter of medical devices to the United States. The outbreak of pandemic and implementation of MRPs put the supply chain into risk and contributed to a huge amount of revenue loss (Nicola et al., 2020). Besides, patients reported reduced contact with healthcare providers due to the fear of disease contraction (Okereke et al., 2021). The limited communication between patients and healthcare providers can bring great damage to the otherwise normal healthcare system. Zhang et al. (2020) used a big data approach to measure individual healthcare expenditure and utilization in mainland China. By tracking healthcare utilization before, during and after the Spring Festival in 2020 and 2019, they concluded that total healthcare expenditure and utilization declined by 37.8 and 40.8%, respectively. Due to the pandemic, finite healthcare resources and government grants for healthcare services are allocated to battle COVID-19 (Edoka et al., 2021), thus, many patients have to delay their necessary healthcare such as surgery, dialysis, cancer treatment, physical rehabilitation, and mental healthcare treatment with disruption in services. An investigation established among older adults across 27 European countries found that the prevalence of reported postponed medical care was up to 26% (Ksinan Jiskrova et al., 2021). The sharp decrease in healthcare utilization can lead to turmoil within the healthcare system. Besides, the post-pandemic increase in healthcare facilities admission of indigent patients, medical reimbursement decrease, and high operating costs to main healthcare workers are all contributing factors to the tsunami of healthcare system induced by COVID-19 (Arredondo et al., 2021).

Healthcare workers (HCWs) as primary personnel within the healthcare system suffer from unprecedented burdens due to the pandemic. A narrative review conducted by Giorgi et al. (2020) recognized HCWs as one of the most vulnerable worker categories that may have negative COVID-19-related mental health effects. During the outbreak period of COVID-19, many HCWs applied for going to the frontline to save more lives. However, they had to face a lot of challenges including reducing the spread of infection of COVID-19, developing suitable short-term strategies for patients, and formulating long-term plans to cope with the aftershock of this pandemic. Alshekaili et al. (2020) investigated the healthcare settings in Oman and compared mental health outcomes between frontline HCWs and non-frontline HCWs during COVID-19. They found that HCWs in the frontline group were 1.5 times more likely to report anxiety, stress, and insomnia. The time pressure, increasing workload, and infection risk are all potential "whirlpools" that can drive HCWs to fall into emotional exhaustion, depression, and anxiety (Liang et al., 2020; Que et al., 2020; Wang H. et al., 2021). Even not during the period of pandemic, experiencing high emotional exhaustion has become a daily routine for many HCWs. In the case of United Kingdom, between 31 and 54.3% of doctors reported a high level of emotional exhaustion before COVID-19 pandemic, not to mention the extreme turmoil condition after pandemic (Imo, 2017). Sticking to the frontline work position means the vacancy in the family position. It has been reported that impaired mental wellbeing such as higher severity of depression and psychological stress lowered the social aspect of the quality of life among healthcare workers during COVID-19 pandemic which is believed to be the consequence of mental disturbance and further worsen the already lowered social interaction within the HCW population due to their commitment in battling the pandemic and saving lives (Woon et al., 2021b). HCWs worry about the health condition and infectious possibility of their families but are not able to take action to protect their families directly by themselves. The worries, feelings of guilt, loneliness, and poor sleep quality all contribute to the consistent reports of HCWs' stress, anxiety, and depressive symptoms (Shreffler et al., 2020; Di Filippo et al., 2021; Repon et al., 2021). Moreover, compared to the other population, HCW were shown to be at nearly three times the risk of infection (Quigley et al., 2021). Even if they are lucky enough to avoid infection, they witness countless infectious cases every day. Hence, it is very easy for them to catch acute stress symptoms or even post-traumatic stress symptoms (PTSS). Yuan et al. (2021) did a meta-analysis on the prevalence of PTSD after infectious disease pandemics in the 21st century and found that HCWs had the highest prevalence of PTSD

report (26.9%) compared to the general population and infected patients. A similar review established by d'Ettorre et al. (2021) focused only on the COVID-19 pandemic induced PTSS and reported a rate of up to 73.4% in regarding to the occurrence of PTSS in HCWs. Social support, referring to a high level of social interaction and communication, is believed to be a protective factor for HCW's mental health wellbeing (Pollock et al., 2020; d'Ettorre et al., 2021; Peng et al., 2021).

Unemployment Under COVID-19 and Associated Mental Health Problems

In the wake of COVID-19, workers were trapped in precarious employment with a large number of people losing their jobs (Matilla-Santander et al., 2021; Strauss et al., 2021). Pinilla et al. (2021) estimated the unemployment rate in the Spanish employment market in 2020 and found that there was a cumulative increase of 11.9% in the rate of unemployment due to the outbreak of COVID-19. Millions of people, especially those in low-income and middle-income countries, have been pushed into extreme poverty (Barlow et al., 2021). As for the hospitality labor market, business closure policies were associated with a 20–30% reduction of non-salaried workers in the food/drink and leisure/entertainment sectors during March-April of 2020 (Huang et al., 2020). The healthcare sector as the fourth-largest employer in India was reported to face 90% losses due to decreases in out-patient attendance, elective surgeries and international patients, not to mention the healthcare workers individual losses (Gopalan and Misra, 2020). In Hong Kong, the unemployment rate increased from 3.7 to 4.2% and the underemployment rate jumped from 1.5 to 2.1% between January and March (Kaur et al., 2020). An inevitable side effect of losing jobs is the loss of their insurance coverage, which further adds burdens to unemployed families, especially those with patients of chronic disease or preexisting mental health disorders (Arredondo et al., 2021).

Research has established a strong association between mental health and work loss or financial insecurity (Bambra, 2011; Reeves et al., 2016). Sudden layoffs and unemployment due to the pandemic contribute to individuals' depression, alcoholism, substance abuse, and even in some cases suicides (Brenner and Bhugra, 2020; Rasul et al., 2021; Shi et al., 2021b), not to mention many unemployed status is long-lasting. Not just the unemployed, the underemployed individuals have also been found to have significant psychosocial stress, annoyance, depression, unfriendliness, and insecurities (Kaur et al., 2020). In fact, even though the labor market started to recover rapidly after the peak period of outbreak, the unemployment rate remained high, for example, in the United States, the unemployment rate remained at 6.9% in October 2020 (Yao and Wu, 2021). Bocchino et al. (2021) concluded a new syndrome of the unemployed which is generally devastating for individuals and families. They found a greater symptomatology of the unemployment syndrome in the unemployed compared to the employed as stress, deterioration of the quality of life, low self-esteem, hopelessness, low personal satisfaction, anxiety, hostility, impotence, frustration, sleep pattern disorders, fear, feeling of irritability, and lack of adaptive resources and management of stressors. Besides, the unemployed scored higher in abuse of alcohol, tobacco and other harmful substances, which may further develop into substance abuse without a proper coping strategy (Bocchino et al., 2021). Within all the named symptoms of the unemployed syndrome, losing the meaning of life and individual functioning is the most struggling for many individuals, which is the culprit that can give people the biggest blow (Thill et al., 2020; Levy and Cohen-Louck, 2021; Rosen and Stenbeck, 2021). As employment and personal/household income are the most direct factors related to individuals' mental health conditions in their daily lives, we summarized existed studies that compared unemployed individuals and employed individuals regarding their mental health problems in **Table 2** (Banna et al., 2020; Liu et al., 2020; Patabendige et al., 2020; Ueda et al., 2020; Verma and Mishra, 2020; Hassannia et al., 2021; Munoz-Navarro et al., 2021) and the association between income and mental health problems in **Table 3** (Banna et al., 2020; Naser et al., 2020; Que et al., 2020; Shi et al., 2020; Verma and Mishra, 2020; Munoz-Navarro et al., 2021; Zheng et al., 2021a). By comparing symptoms of anxiety and stress between the employed and unemployed, Banna et al. (2020) reported that unemployed individuals were three times more likely than the employed to have anxiety symptoms and two times more likely to have stress (Banna et al., 2020). The likelihood of suffering from depression among the unemployed was shown to be as about twice as that among the employed (Verma and Mishra, 2020).

DISCUSSION

In this paper, we reviewed the current status of global major economies with the influence of the COVID-19, mental health problems induced by the outbreak, as well as particular sectors seriously damaged by the outbreak and related mental health responses. After comprehensively reviewing existing literatures, we propose a progressive relationship between the pandemic, economic slowdown, and negative mental consequences. In summary, outbreak of COVID-19 induced the imbalance of demand and supply in the world market, and the affected international trade contributed to depressive symptoms of those who rely on international supply chains to earn lives. Similarly, limitation of travel across countries due to the pandemic has put tourism economy into gloomy, and as a consequence, those who work in the tourism industry, who travel to spend their leisure time, or those who travel to earn knowledge and experience cultural exchange would suffer from negative feelings such as loneliness, discrimination, anxiety, depression, and even PTSD symptoms. Impact on the education system of COVID-19 pandemic was mainly reflected through school closure, and associated with quarantine, internet addiction behavior, parents' working hour contraction, and students' dropout. The major mental consequences of these changes in economic activities induced by the pandemic were seclusion, panic attacks, comorbid sleep problems, and depression in more serious cases. Healthcare system is another severely vibrated social system by COVID-19. Imbalanced medical resource allocation and declined

TABLE 2 | Summary of findings comparing prevalence of mental health problems between the employed and the unemployed.

References	Site	Participants	Outcomes	Prevalence among the employed	Prevalence of the unemployed	OR (reference: employed)
Banna et al. (2020)	Bangladesh	general	depression	42.3% (153/362)	77.0% (106/138)	/
		population	anxiety	28.2% (102/362)	48.9% (67/138)	4.28 (2.47–7.40)
			stress	56.4% (204/362)	71.9% (99/138)	3.20 (1.97–5.18)
Hassannia et al. (2021)	Iran	health	depression	Physician: 52.0%	41.9% (31/74)	/
(2021)		workers	anxiety	(66/127); Nurse: 51.4% (54/105) Physician: 68.5% (87/127); Nurse: 68.6% (72/105)	59.4% (44/74)	/
Liu et al. (2020)	Turkey	general	depression	26.8% (33/123)	37.0% (10/27)	/
		population	anxiety	10.7% (13/122)	29.6% (8/27)	/
Munoz-Navarro et al. (2021)	Spain	general	depression	9.4% (79/838)	searching for work: 19.6%	1.17
		population	anxiety	12.8% (107/838)	(43/219); not searching for work: 15.0% (28/187) searching for work: 24.2% (53/219); not searching for work: 16.0% (30/187)	1.02
Patabendige et al. (2020)	Sri Lanka	pregnant	depression	18.2% (10/55)	30.2% (55/182)	/
		women	anxiety	20.0% (11/55)	21.4% (39/182)	/
			both depression and anxiety	5.5% (3/55)	9.3% (17/182)	
Ueda et al. (2020)	Japan	general	depression	18.9%	31.2%	/
		population	anxiety	11.7%	25.4%	/
Verma and Mishra (2020)	India	general	depression	19.3% (27/140)	29.0% (62/214)	1.91 (1.07–3.42)
		population	anxiety	22.1% (31/140)	31.8% (68/214)	1.77 (1.00–3.14)
			stress	10.0% (14/140)	12.6% (27/214)	1.25 (0.57–2.72)

healthcare utilization is related to negative consequences of relevant economic activities as well as mental health problems of healthcare personnel and patients. Adverse mental experiences of HCWS, especially frontline HCWs, have been extensively studied. Precarious employment was a problem suffered by millions of people following the outbreak of COVID-19. Unemployed and underemployed individuals suffer from not only physical, but also mental hardship.

With the realization of the huge economic turmoil brought by COVID-19 pandemic and so many sectors affected, governments across the globe should take actions to mitigate the economic loss and mental health burden. First, the government should consider its own situation and come up with economic recovery policies targeting at the sectors mostly affected by the pandemic. For example, as face-to-face interaction between healthcare professionals and patients or between teachers and students have been limited, productivity by embracing digital manufacturing technologies can be increased in a more cost-effective marketing strategy in order to keep the balance of healthcare and education systems (Lodha and De Sousa, 2020; Kim and Lee, 2021). Aforementioned MRPs should also be cautiously applied by different governments. Although studies in China showed that isolation-and-quarantine was the most cost-effective intervention in controlling COVID-19, results of studies in other countries can be inconsistent (Rezapour et al., 2021). Therefore, when publicizing strategies to limit virus transmission, the national economic burden as well as individuals' psychological responses should be considered. Second, we suggest governments or policy makers in different countries to share information and experience in dealing with COVID-19-induced economic slowdown and promote herd immunity worldwide to the *status quo* of the normalization of epidemic prevention. The vaccine can be a strong candidate in controlling the COVID-19 outbreak as well as saving economic loss due to the outbreak as it can help the public to acquire herd immunity in a shorter period which is an effective weapon in fighting against the virus (Sarkodie and Owusu, 2020; Zheng et al., 2021b). Waiting for herd immunity achievement through natural infecting is expected to lose 0.42 years of life per capita compared to the pre-pandemic situation (Gandjour, 2020). A study in the

TABLE 3 | Summary of findings exploring the association between income and mental health problems.

References	Site	Participants	Outcomes	Prevalence in low income group	Prevalence in high income group	OR (reference: low income)
Banna et al. (2020)	Bangladesh	general population	depression	55.2% (199/360)	57.1% (254/445)	/
			anxiety	29.5% (106/360)	36.9% (164/445)	1.49 (1.11–2.22)
			stress	53.2% (191/360)	63.8% (284/445)	1.67 (1.18–2.33)
Munoz-Navarro et al. (2021)	Spain	general population	depression	17.2% (43/250)	3.2% (4/125)	/
			anxiety	20.4% (51/250)	12.8% (16/125)	/
Naser et al. (2020)	Jordan	general population	severe depression	/	/	0.50 (0.30–0.82)
			severe anxiety	/	/	0.70 (0.39–1.26)
		health worker	severe depression	/	/	0.38 (0.20–0.71)
			severe anxiety	/	/	0.42 (0.18–0.98)
		university student	severe depression	/	/	1.48 (0.81–2.70)
			severe anxiety	/	/	1.95 (1.03–3.70)
Que et al. (2020)	China	health worker	depression	/	/	0.45 (0.25–0.80)
			anxiety	/	/	1.01 (0.60–1.71)
			insomnia	/	/	0.60 (0.28–1.27)
Shi et al. (2020)	China	general population	depression	/	/	0.74 (0.69–0.78)
			anxiety	/	/	0.75 (0.71–0.79)
			insomnia	/	/	0.91 (0.86–0.96)
			stress	/	/	0.79 (0.77–0.84)
Verma and Mishra (2020)	India	general population	depression	25.9% (15/58)	25.0% (74/296)	0.91 (0.46–1.75)
			anxiety	27.6% (16/58)	28.0% (83/296)	0.83 (0.42–1.61)
			stress	8.6% (5/58)	12.2% (36/296)	0.72 (0.26–2.04)
Zheng et al. (2021a)	China	older adults (age >50)	depression	22.6% (201/888)	16.7% (184/1100)	0.74 (0.57–0.96)
			anxiety	30.7% (273/888)	22.6% (249/1100)	0.68 (0.53–0.85)
			insomnia	28.2% (250/888)	25.7% (283/1100)	0.97 (0.77–1.22)
			stress	23.8% (211/888)	17.1% (188/1100)	0.69 (0.53–0.90)

United States suggested that social distancing would not be a cost-effective strategy unless an effective therapy or vaccine could be introduced within 11.1 months of late May 2020 (Thunstrom et al., 2020). Increasing studies have been established and informed the vaccination prioritization (Kohli et al., 2021; Padula et al., 2021; Wang W. C. et al., 2021). Third, stigmatization resulted from misinformation and invalid communication can hinder the application of cost-effective strategies in flattening the COVID-19 curve. Moreover, stigmatization toward mental problems plays a significant and negative role in increasing the psychological burden of individuals with mental health problems, especially in some low-income countries with inadequate mental health services (Kuruthukulangara and Goyal, 2020). In order to minimize the adverse consequence of COVID-19 pandemic and economic shock on the public mental health status, mental health sectors around the world are encouraged to communicate, cooperate and work together when necessary to protect the mental wellbeing of people around the world. We encourage more valid and effective international communications and cooperation in controlling the virus transmission, economic loss, and increased mental health problems induced by the pandemic.

Even though we made efforts to review existing literatures as thoroughly as possible to reveal the economic consequences of COVID-19 and successive mental problems, there are still some limitations in the current article. It is difficult for us to conclude a causal or directional relationship between COVID-19, economic slowdown, and mental health problems. We can only propose a progressive relationship between the three based on current literatures with limited data sources. Besides, we can only display the interrelationship between the three macroscopically. We were unable to look more deeply into the condition of each nation due to the lack of data support in many developing or low-income countries.

Broadly speaking, COVID-19 had induced economic slowdown and adverse mental consequences worldwide with a proposed progressive relationship in between. International trade, worldwide travel, education system, healthcare system, and individual employment condition are major economic aspects that have been affected by COVID-19 pandemic. Loneliness, insecurity, anxiety, depression, sleep problems, discrimination, and substance abuse are adverse mental consequences experienced by individuals experiencing economic

turmoil during the pandemic. We call on countries to strengthen cooperation and communication and actively adopt a broad range of economic recovery programs including the adoption of digital and remote trade, education and medical programs and COVID-19 vaccine popularization plan to promote economic recovery to further improve the wellbeing of mental health among multiple vulnerable population worldwide.

AUTHOR CONTRIBUTIONS

LL, YB, and SM designed the idea of review and revised the manuscript. YG and XL wrote the draft manuscript. XL, YZ, and HM constructed figures. JQ, KY, WY, and LS reviewed and edited the manuscript. All authors contributed equally to the idea of the manuscript and approved the final manuscript.

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Who Can Get More Happiness? Effects of Different Self-Construction and Experiential Purchase Tendency on Happiness

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This study introduces the self-construction methods of consumers and the tendency characteristics of experiential purchase to study the effects of physical purchase and experiential purchase on wellbeing. The dependent self-builders obtain higher happiness from experiential purchase; however, the independent self-builders get higher happiness from physical purchase. Furthermore, consumers with a high purchase experience get higher happiness from experiential purchase. Consumers with high material consumption tendency get significantly higher happiness than physical purchase from experiential purchase. Consumers with high materialism tendency gain higher happiness in experiential purchase, which is in line with the expectations of self-construction and consumption theories. This study provides the first evidence for the impact of self-construction methods on wellbeing with different consumption choices.

Keywords: self-construction, experiential purchase tendency, consumption effect, evaluation, experiential purchase propensity

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INTRODUCTION

The disposable income of Chinese residents has been increasing since the mid-2010s. After meeting the basic living needs, they can consume more and more products to meet their material and spiritual needs. At this point, obtaining more happiness through consumption has become a research hot spot of scholars (Van Boven and Gilovich, 2003; Carter and Gilovich, 2012; Tully et al., 2015; Weidman and Dunn, 2016; Aknin et al., 2020). Current consumer psychology researchers mainly study the antecedents of consumption and the decision-making process (Howell and Hill, 2009; Dunn et al., 2011; Carter and Gilovich, 2014). The study has found that consumer personality traits can affect the wellbeing evaluation of consumer behavior, among which materialism is the most concerned trait of consumer personality traits, and materialism tends to buy in kind and obtain happiness by highlighting material possession (Van Boven and Gilovich, 2003; Tully et al., 2015; Weidman and Dunn, 2016).

Self-construction as an important personality trait of consumer self-mediation also has important implications for the wellbeing evaluation of consumer behavior. Research of scholars on how self-construction affects consumption patterns is mainly based on group research and individual consumer research. Based on the perspective of group study, Guo et al. (2010) studied the influence of self-construction on happiness by comparing the Chinese and the Western societies. Research on individual consumers is still relatively lacking. As a

personality trait, experiential purchase tendency was proposed by Howell et al. (2012), and it also affects consumption tendency and consumption effect evaluation.

At this stage, due to the lack of research on the self-construction mode of consumers on consumption effect, this study explores the influence of self-construction mode and experiential purchase intention on consumer purchase intention and the evaluation of consumption effect through empirical research.

The rest of this study is organized as follows. The "Theoretical review and hypotheses" section reviews the theoretical background and explains the hypotheses in this study. The "Empirical results" section discusses the empirical results. The "Conclusion" section concludes.

THEORETICAL REVIEW AND HYPOTHESES

Happiness

Happiness is a very subjective positive experience after individuals evaluate their own life experiences according to their standards. According to the study by Diener (2000), individuals believe that their existing life is an affirmative attitude and feeling of their ideal life, where positive psychology calls subjective wellbeing (SWB).

Kahneman and Deaton (2010) suggested that happiness refers to the emotional state of a certain moment, called objective wellbeing (objective happiness), which is affected by situational behaviors such as certain display frameworks, i.e., prosocial behavior (Mogilner, 2010). The objective happiness measure requires the subject to score the current happiness, such as "Now, the degree of happiness you feel is?" The current happiness of subjects is measured by a 7-point Likert scale.

Happiness is a narrow concept than subjective happiness. There are many factors affecting happiness, and the most mentioned are material conditions and consumption, as well as family and social relations. Happiness increases with income and also decreases with income, and the relationship between income and happiness is shown in parallel in individuals with high-income levels. It is found that the overall national level of national happiness will not change over time and is not related to the increase of gross domestic product (GDP) *per capita*, which is called the "Easterlin Paradox." Happiness comes from a balance of positive and negative emotions; although the concept of happiness is narrower than SWB, Aristotle equated happiness with subjective happiness. It is believed that subjective happiness is in a happy state, and despite the differences, the researchers have always taken "happiness" as a measure of happiness. Happiness tests characterize the wellbeing of people who are reporting the happiness they feel.

The concept of wellbeing adopts the concept of objective wellbeing, drawing on the wellbeing measurement scale developed by Kahneman and Deaton (2010), to better adapt to the experimental needs, "the degree of happiness you feel is? "Change to" the happiness you feel?" The current happiness of subjects is measured by a 7-point Likert scale.

Experiential Purchase and Physical Purchase

Different consumers have different emphases on daily consumption tendencies. Some consumers tend to buy physical products such as computers, cars, and clothing. Some consumers tend to buy experience products such as tourism and outdoor activities. Scholars summarize this behavior phenomenon into two types of consumption, namely, experiential purchase, and physical purchase. Experiential purchase refers to purchases for life experience or experience, such as watching movies, traveling, and listening to concerts. Physical purchase refers to purchasing to own something, such as a bag and a mobile phone (Van Boven and Gilovich, 2003).

Different consumption tendencies bring different happiness. Physical purchase emphasizes the preservation and possession of goods. Also, in experiential purchase, consumers can only feel and enjoy in a limited time (Carter and Gilovich, 2012; Li et al., 2021). Different consumption tendencies have great differences in consumer happiness. Many studies have shown that experiential purchase brings more happiness than physical purchase. Scholars study the influence of different consumption activities on happiness from the perspective of self-determination theory, social comparison theory, and explanatory level theory (Dunn et al., 2011; Pham, 2015; O'Brien and Kassirer, 2019; Falk and Graeber, 2020; O'Neill, 2020; Ding et al., 2021; FitzRoy and Nolan, 2021). Personality traits are also an important factor in studying the impact of consumption patterns on happiness (Gilbert et al., 1995; Liberman and Trope, 1998; Deci and Ryan, 2000; Kumar and Gilovich, 2016; Mann and Gilovich, 2016; Matz et al., 2016).

Researchers study the impact of purchase types on the happiness of consumers from two large levels. Experiential purchase over time has different impact mechanisms from a physical purchase on happiness from the individual level. The positive experience is better over time, and even negative experiences will pass through time. Through the processing of the consumer, the memory becomes a special experience; experience is part of the self-concept of consumers, and the life of an individual is the synthesis of their life experience. Also, the physical purchase over time will gradually fade until the happiness of the consumer is lost. From the interpersonal perspective, experiential purchase is based on personal feelings, which is more subjective than social comparison. In contrast, the physical purchase is easy to reduce the happiness of consumers in the social comparison; experiential purchase is happier than physical purchase (Kumar and Gilovich, 2015, 2016), which puts forward the following assumptions according to the above theory in order to verify those assumptions through empirical research:

H1: Individuals get more happiness from experiential purchase than physical purchase.

Interdependent Self-Construal and Independent Self-Construal

Markus and Kitayama (1991) put forward the concept of self-construction, based on cultural differences between China

and the West on the formation of self-concept to represent the relationship between individuals and the outside world. Interdependent self-construal focuses on relationships with others and defines themselves through harmonious relationships (Markus and Kitayama, 1991). The authors usually represent themselves in interpersonal relationships and tend to experiential purchase. The experiential purchase is conducive to establishing social relations (Carter and Gilovich, 2014). Experiential purchase is also the process of establishing social relations.

Independent self suggests that the characteristics of every person are unique. When they respond to the social environment, the response is not only for the environment itself but also for the needs of the social situation which is also important. Still, they only serve as reference standards to strengthen the inner self. Independent self-builders can feel the immediate pleasure brought by consumption and are more likely to yield to the desire for consumption. The physical object has the characteristics of "here and now," which is the objective existence of the present and can bring immediate pleasure to consumers.

Individuals define the self through their relationship with others, believing that neither self nor others can be separated from the situation but integrated with specific situations. The core concept is the harmony between self and others and creates harmonious relationships by adjusting themselves (Markus and Kitayama, 1991; Singelis, 1994). The individuals rely on others and adjust their behavior through their relationship with others and social situations. They attach importance to establishing relationships with others and various interpersonal relationship networks. The focus and core of the dependent self-builder is not the inner self but the collection of relationships between individuals and others. Lending to adjust themselves to create harmonious relationships, experiential purchase is conducive to build social relationships (Van Boven, 2005; Carter and Gilovich, 2014) experience consumption is easier to share, not only promote relationships, but also gain respect, and enhance individual happiness (Van Boven et al., 2010; Kumar and Gilovich, 2015).

Experiential consumption is easier for others to share, promoting relationships and gaining respect, conducive to improving individual wellbeing (Kumar and Gilovich, 2015). Independent self-construal is usually expressed themselves by internal traits. At the same time, physical consumption is a relatively isolated process, and the consumption process is also a process for consumers to establish self-awareness. Independent self-construal can feel the immediate pleasure brought by consumption and more likely to succumb to the desire for consumption. Physical objects have the characteristics of "here and now," which is the objective existence of the moment and can bring instant pleasure to consumers. Based on this, the following assumptions are put forward:

H2: There are significant differences in the self-construction of happiness gained in different consumption activities.

H2a: Self-builders gain more happiness in their experience and buying.

H2b: Independent self-builders gain more happiness in physical purchases.

Materialism and Experiential Purchase Tendency

Howell et al. (2012) first proposed an experiential purchase tendency. Individuals tend to buy experiential products in their daily purchases, paying more attention to their own internal experience than to their physical possessions. The experiential purchase tendency is also a personality trait. Different individuals are relatively stable and will not change easily (Howell and Hill, 2009). Unlike the repetition of purchase behavior of physical purchase, the experiential purchase of each tourism and each concert will bring great differences in different experiences for individuals. Many of these experiences are difficult to predict and cannot be repeated. They often give individuals more emotional stimulation and bring more happiness. High happiness leads to the more experiential purchase of individuals and forms a personality trait, which becomes a stable purchase tendency. The Experiential Buying Tendency Scale (EBTS) was developed by Howell et al. (2012).

Materialists (non-experience buyers) regard the acquisition of material wealth as the main goal of life struggle and even ignore other goals such as belonging and self-acceptance. Materialists have lower satisfaction with life and higher depression. They do not attach importance to their interpersonal relationship and are not satisfied with the quality of their interpersonal relationship (Kahneman and Deaton, 2010). Lack of trust in others, lack of social support, low sense of connection with others and society, lack of sense of belonging, and lack of social support lead to lower happiness. Although materialists believe that material possession can bring them the greatest happiness, when they are randomly assigned to physical purchase and experiential purchase groups, the subsequent happiness measurement shows that experiential purchase still brings them greater happiness (Carter and Gilovich, 2014). Materialism is not conducive to the improvement of the happiness of the people. Based on this, the following assumptions are made:

H3: The consumption tendency is different, and consumers feel different happiness in different ways of consumption.

H3a: Those who experience purchase tendency can get significantly more happiness in experiential purchase than physical purchase.

H3b: Materialists get significantly more happiness in experiential purchase than in physical purchase.

Reliability and Validity Test

At present, the measurement of self-construal is mainly quantitative measurement. Singelis (1994) developed the self-construal scale (SCS) scale, which is widely used. The scale consists of 24 test items, of which 12 are independent self-construal and 12 are interdependent. This study uses the SCS

scale. According to the self-constructed scale in Experiment 2, Cronbach's alpha is 0.895, Kaiser-Meyer-Olkin (KMO) is 0.856, and $p < 0.000$, indicating that the reliability and validity of the scale are good, which is suitable for the analysis of this questionnaire.

According to the Richins' Materialism Scale, which has nine items, the last is the reverse question, and Howell et al. (2012) developed the Experiential Purchase Tendency Scale (i.e., EBTS) that has four items. According to Materialism Scale and the Experiential Purchase Intention Scale in Experiment 3, Cronbach's alpha of the Materialism Scale is 0.766, KMO is 0.836, and $p < 0.000$, and Cronbach's alpha of the Experiential Purchase Tendency Scale is 0.812, KMO is 0.887, and $p < 0.000$, indicating that the reliability and validity of the two scales are good, which are suitable for the analysis of this questionnaire.

EMPIRICAL RESULTS

Experiment 1

The purpose of this experiment is to verify hypothesis H1.

Pretest

The purpose of the pretest was to determine whether the description of "physical purchase" and "experiential purchase" in Experiment 1 was appropriate. This study used the method developed by Carter and Gilovich (2012) to investigate experiential and physical purchases. Let the subjects read, imagine you are making a purchase decision: You are going to buy a new phone.

Here are two descriptions. Description 1: the mobile phone you are about to buy is a relatively high-end mobile phone in the market. The metal fuselage, ceramic touch, fuselage fine grinding, corrosion resistance, high stability of the six-layered spraying process, and unique camera design make the vision clearer and wider. Everyone knows that the mobile phone is very advanced. When you hold it in your hand, it is very attractive.

Description 2: the mobile phone you are about to buy is a relatively new and high-end model. The screen of the mobile phone is very touchy and warm. The camera shooting function of the mobile phone is more powerful, and it can take a clearer picture of the wonderful moments in your life. It can also edit photos according to your preferences to have more different and better experiences.

Then, let the pretest subjects answer the following two questions: (1) you think description 1 focuses more on physical description or experience description, using a 7-point Likert scale (1 = physical description and 7 = experience description) score and (2) you think description 2 focuses more on physical description or experience description, using Likert scale score. Through the analysis of 40 sample data, $M_{physical} = 2.55$, which is significantly lower than the median value 4 ($t = -8.453$, $p < 0.000$), indicating that description 1 is the physical description in manipulation. $M_{experience} = 5.88$, significantly higher than the median 4 ($t = 12.297$, $p < 0.000$), indicates that description 2 is the experience description in manipulation, and the data show that the manipulation is successful, so in the experiment, description 1 is purchased as physical, and description 2 is purchased as experience.

Experimental Participants and Procedures

The formal participants were 135 undergraduate students from a university in Guangzhou, with 119 valid respondents, including 43 male students (36.1%) and 76 female students (63.9%), with an average age of 21.46 years ($SD = 3.46$).

Step 1: Tell the subjects that we are experimenting on consumption choices. First, let all the subjects read the above materials, and then, let the subjects rate description 1 and description 2 belonging to physical description or experience description, respectively.

Step 2: Let the subjects choose one of their favorite descriptions from the above, using the scale developed by Carter and Gilovich (2014), and ask the subjects to score the degree of happiness they feel at present (e.g., "Now, what is the degree of happiness you feel?" 1 means very unhappy, and 7 means very happy).

Step 3: Finally, ask the subjects whether they know the purpose of the investigation, let them fill in the personal data.

Experimental Result Analysis

Manipulation Test

Subjects were asked to score whether descriptions 1 and 2 belonged to physical or experience descriptions; description 1 belonged to physical or experience description, $M_{physical} = 2.45$, which was significantly lower than the median value 4 ($t = 12.65$, $p < 0.000$), whereas description 2 belonged to physical or experience description, $M_{experience} = 5.45$, which was significantly higher than the intermediate value 4 ($t = 8.43$, $p < 0.000$). The manipulation test data show that physical description and experience description are successfully manipulated.

Hypothesis Testing

By calculating the average happiness of the participants who choose physical purchase and those who choose experiential purchase in the questionnaire, the descriptive statistical scale in **Table 1** is obtained as follows. One-way ANOVA showed that $F(1, 117) = 54.25$, $p < 0.000$, $M_{physical} = 4.03$, ($SD = 1.38$), and $M_{experience} = 5.72$, ($SD = 1.04$), indicating that there was a significant difference in happiness between physical purchase and experiential purchase. Thus, hypothesis H1 was verified.

The experiment verifies that "experiential purchase" can bring consumers more pleasure and happiness than physical purchase (Van Boven and Gilovich, 2003; Howell and Hill, 2009; Carter and Gilovich, 2012). Purchasing in-kind fades away with time, individual experience can become part of the individual concept

TABLE 1 | Descriptive statistics of the difference in happiness.

Consumption type	M	SD	N	95% Confidence interval	
				Lower limit	Upper limit
Physical purchase	4.027	0.191	62	3.649	4.405
Experiential purchase	5.720	0.128	57	5.466	5.973

through memory. The life experience of a person is their life, so the experiential purchase can bring an individual more happiness.

Experiment 2

This experiment verifies the hypotheses H2, H2a, and H2b that self-construction of different people in the happiness of physical and experiential purchase significantly differs.

The formal participants were 245 undergraduate students from a university in Guangzhou, with 237 valid respondents, including 87 male students (36.7%) and 150 female students (63.3%), with an average age of 21.22 years (SD = 3.62).

Experimental Participants and Procedures

Step 1: Tell the subjects that we are experimenting on consumption choices to get the subjects to make a purchase decision. The introduction to the experiment is as follows: Imagine that you are facing a purchase challenge right now because budgets are limited, and you can only choose one. You are considering buying a branded mobile phone with a powerful CPU, memory, storage, the favorite imaging quality of an industry, IOS program response speed and memory management, and strong product hedging capabilities. At the same time, you also consider that if you do not change your new mobile phone, you can use this expenditure to travel to Tibet, where there are continuous snow mountains, quiet lakes, seemingly reachable clouds, azure sky, and the Potala Palace, which has long been your dream. Then, let the subjects choose, fill in the happiness scale developed by Kahneman and Deaton (2010), and fill in the Single SCS scale.

Step 2: Let the subjects score the degree of happiness that the decision can feel.

Step 3: Finally, ask subjects if they know the purpose of the investigation and fill out the personal information.

Experimental Data Analysis

This experiment adopted 2 (construction mode) × 2 (consumption type) between-group experiments. First, the reliability and validity of the self-construction scale in the questionnaire were analyzed. The Cronbach's alpha was 0.895, and the KMO was 0.856 ($p < 0.000$), indicating that the reliability and validity of the scale were good, which was suitable for this survey.

Through simple descriptive analysis of the happiness of different consumption types under different construction types, **Table 2** is obtained.

Taking the happiness degree of the subjects as the dependent variable and the construction type and the consumption type as the independent variables, the single-factor ANOVA is carried out. The results showed that the interaction between different construction methods and consumption types was significant $F(1, 233) = 70.805$, $p < 0.000$, as shown in **Figure 1**. The $M_{experience}$ of the dependent construction is 5.625, and the $M_{physical}$ is 4.581, whereas the $M_{experience}$ of the independent construction is 4.723, and the $M_{physical}$ is 5.694, $F(1, 233) = 31.09$, $p < 0.000$, which has a significant difference. Self-construal of different people in different consumption patterns of happiness has been significantly different, and hypothesis H2 is verified.

In the context of dependent construction, the happiness level of consumption patterns was significantly different $F(1, 156) = 33.162$, $p < 0.000$, indicating significant differences in the degree of happiness in the same self-construction context experienced by participants in different consumption types. The degree of happiness experienced by the physical purchase subjects $M_{physical} = 4.58$ ($SD = 1.222$), the degree of happiness experienced by the experimental purchase subjects $M_{experience} = 5.63$ ($SD = 0.669$), and the degree of happiness between experiential purchase and physical purchase is significant [$t(95) = 15.308$, $p < 0.000$]. This evidence shows that in the interdependently constructed group of subjects, the degree of happiness that the subjects feel from experiential purchases is significantly higher than that of physical purchases. It is assumed that the happiness of H2a-interdependent self-construal in the experiential purchase is significantly higher than that in physical purchase.

In the context of independent self-construal, there is a significant difference in the level of happiness among different consumption types $F(1, 77) = 3.191$, $p < 0.000$, indicating that in the context of independent self-construal, there is a significant difference in the degree of happiness that physical purchase and experiential purchase subjects can experience. The degree of happiness that $M_{physical\ object}$ is 5.69 ($SD = 0.738$), the degree of happiness that $M_{experience}$ is 4.72 ($SD = 0.615$), and the degree of happiness that physical purchase and experiential purchase are significantly different [$t(31) = 7.418$, $p < 0.000$]. The results showed that subjects felt more happiness from the physical purchase than physical purchase in the independent self-construal group. It is assumed that H2b-independent self-construal obtains significantly higher happiness in physical purchase than experiential purchase.

Experiment 2 explored the difference in happiness between consumers with different self-construction methods in the physical purchase and experiential purchase. The interdependent self-construal indicated more happiness in the experiential purchase, while the interdependent self-construal obtained more happiness in physical purchase. The interdependent

TABLE 2 | Descriptive statistics of the difference in happiness.

Construction types	Consumption type	*M*	*SD*	N	95% Confidence interval	
					Lower limit	Upper limit
Dependency construction	Physical purchase	4.581	1.222	62	4.355	4.806
	Experiential purchase	5.625	0.669	96	5.444	5.806
Independent construction	Physical purchase	5.694	0.738	32	4.779	5.408
	Experiential purchase	4.723	0.615	47	4.464	4.983

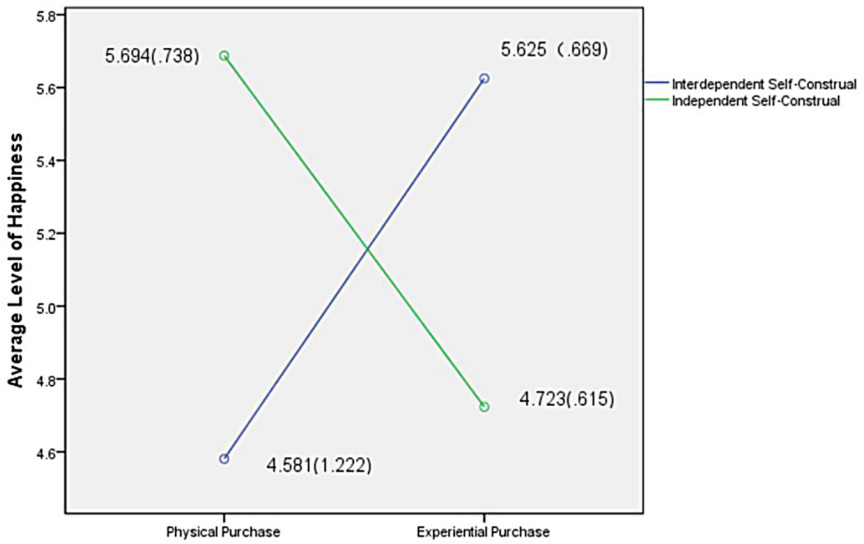

FIGURE 1 | Interaction between constructive style and consumption type.

self-construal tended to define themselves through the relationship with the outside world. The experience consumption process is social, increasing interpersonal intimacy to meet the interdependent self-construal needs for social relations and improve their happiness. Independent self-construal pays more attention to themselves, and the physical purchase is often completed alone, which can meet the needs of independent self-construal self-realization. Thus, the hypotheses H2, H2a, and H2b are verified.

Experiment 3

The purpose of this experiment was to verify H3, H3a, and H3b that people with different materialistic tendencies and experiential purchase tendencies have significant differences in obtaining happiness in the physical purchase and experiential purchase.

Experimental Participants and Procedures

The participants in the formal experiment were 268 undergraduate students from a university in Guangzhou, 256 valid respondents, 116 male students (45.3%), and 140 female students (54.7%), with an average age of 21.66 years (SD = 4.646).

Step 1: Tell the subjects that we are experimenting on consumption choices and get them to make a purchase decision. The preamble to the experiment is as follows: Suppose you are facing a dilemma in consumption decisions because budgets are limited, and you can only choose one from two. Listen to the concert of a favorite singer or buy a large brand of clothing that you have long loved. The concert will make you happy. You can melt yourself into music and embark on a dream journey with melody. And you have a long-loved brand of clothing, and it has a unique design and superior supplies, which will make you feel that you have very grade clothes. Then, let the subjects choose whether they would like to go to the concert or buy their favorite clothes.

Step 2: Let subjects score the degree of happiness based on the above decisions.

Step 3: Then, let the subjects fill in the Materialism Scale and the Experiential Purchase Tendency Scale.

Step 4: Finally, ask the subjects whether they know the purpose of the investigation and fill out the personal information.

Experimental Data Analysis

This experiment adopted 2 (experiential purchase tendency, materialism consumption tendency) × 2 (consumption type) between-group experiments. First, the reliability and validity of the Materialism Scale and the Experiential Purchase Tendency Scale were analyzed. The Cronbach's alpha of the Materialism Scale was 0.766, and the KMO was 0.836, $p < 0.000$. The Cronbach's alpha of the Experiential Purchase Tendency Scale was 0.812, and the KMO was 0.887, $p < 0.000$, indicating that the reliability and validity of the two scales were good, which were suitable for the analysis of this questionnaire. Variables are calculated and converted for the reverse questions of the Materialism Scale. Then, a simple descriptive analysis is carried out on the happiness obtained by participants with different consumption tendencies and consumption types, as shown in **Table 3**.

The results showed that the interaction between different consumption tendencies and consumption types was insignificant $F(1, 252) = -1.763$, $p = 0.185$, as shown in **Figure 2**. One-way ANOVA was conducted with the happiness of participants as the dependent variable and consumption propensity and consumption type as the independent variables. $M_{experience}$ of experiential purchase propensity = 6.174, $M_{physical}$ = 5.423, $M_{experience}$ of materialism consumption propensity = 5.962, $M_{physical}$ = 5.413, $F(1, 252) = 15.527$,

TABLE 3 | Descriptive statistics of the difference in happiness.

Propensity to consume	Consumption type	*M*	*SD*	N	95% Confidence interval	
					Lower limit	Upper limit
Experiential purchase tendency	Experiential purchase	6.174	0.677	46	5.841	6.507
	Physical purchase	5.423	1.027	26	4.980	5.867
Physical purchase tendency	Experiential purchase	5.962	1.123	104	5.740	6.183
	Physical purchase	5.413	1.402	80	5.160	5.665

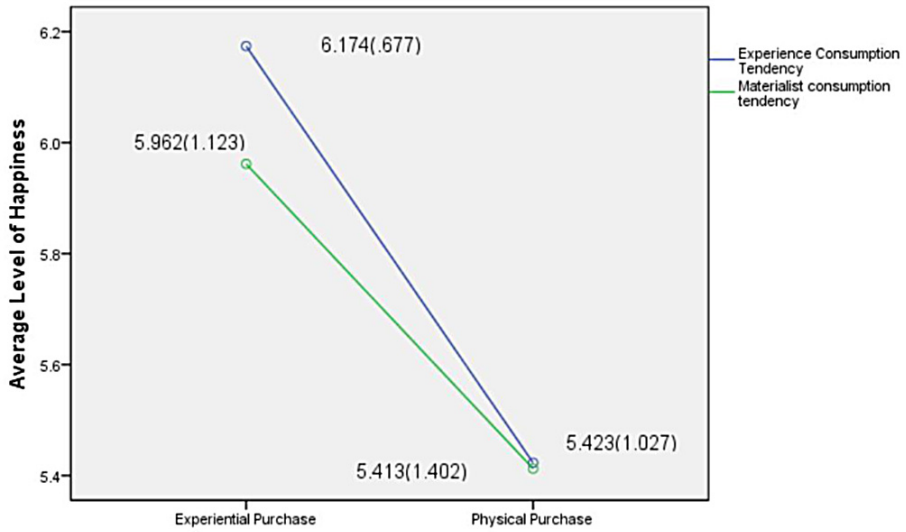

FIGURE 2 | Interaction between consumption tendency and consumption type.

$p < 0.000$, showing significant differences. Assuming that H3 has a different propensity to consume, the significant difference in happiness obtained by participants in the experiential purchase and physical purchase is verified, indicating that participants with different propensity to consume have a significant difference in happiness obtained in the experiential purchase and physical purchase.

In the context of experiential purchase tendency, the main effect of the level of happiness of consumption types was significant $F(2, 70) = 10.226$, $p < 0.002$, indicating that, in the context of high experiential purchase tendency, there were significant differences in the degree of happiness that different consumption types of subjects can experience. The degree of happiness experienced by physical purchase subjects was 5.42 ($SD = 1.027$), the degree of happiness experienced by experiential purchase subjects was 6.17 ($SD = 0.677$), and the difference between experiential purchase and the physical purchase was significant [$t(46) = 7.556$, $p < 0.000$]. This evidence shows that subjects with high experiential purchase tendency feel more happiness from the experiential purchase than physical purchase. Assuming that H3a is verified, experiential purchasers tend to enjoy experiential purchases significantly higher than physical purchases.

In the context of physical consumption tendency, the main effect of the happiness level of consumption types was significant $F(2, 182) = 9.324$, $p < 0.003$, indicating that in the context of high physical consumption tendency, there was a significant difference in the degree of happiness that physical purchase and experiential purchase subjects can experience. The happiness level of physical purchase subjects was 5.41 ($SD = 1.402$), the happiness level of experiential purchase subjects was 5.96 ($SD = 1.123$), and the happiness of different consumption types was significantly different [$t(103) = 5.010$, $p < 0.000$]. This result shows that subjects with a high propensity to physical consumption still feel significantly higher happiness from the experiential purchase than physical purchase. Assuming that H3b is verified, consumers with a high propensity to physical consumption get a higher happy experience from experiential purchase.

The experimental data show that subjects with different consumption tendencies have significant differences in happiness in physical and experiential purchases. Assuming that H3 is validated, subjects with a higher propensity to experiential purchase gain more happiness from experiential purchase. Assuming that H3a is verified, subjects with higher materialistic propensity to consume also have significant differences in happiness from experiential purchase and physical purchase, and experiential purchase brings happiness to subjects significantly higher than physical purchase. We observed that H3b is verified. Although participants with high materialistic consumption tendency expect to obtain more happiness from physical

consumption, they often fall into the "materialistic supremacy" trap. Excessive pursuit of material satisfaction is self-defeating behavior, which brings more negative emotions and depression. Experiential purchase is a kind of social consumption, which can meet the social needs of materialism and correct their extreme emphasis on material pursuit and neglect of the construction of interpersonal relationships. Therefore, subjects with a high propensity to materialistic consumption have significantly higher pleasure in experiential purchase than physical purchase.

CONCLUSION

The main conclusions are as follows: interdependent self-construal gains more happiness from experiential purchase, and independent self-construal gains more happiness from physical purchase. Subjects with a high propensity to experiential purchase gain more happiness from experiential purchase, and subjects with materialism tend to gain more happiness from experiential purchase.

First, it enriches the related research of physical purchase and experiential purchase. Previously, the research on the influence of physical purchase and experiential purchase on the happiness of consumers mainly analyzed the influence of experiential purchase and physical purchase on happiness from construal level theory, self-concept, social comparison, and self-determination theory. This study introduces the self-construction of the personality traits of consumers, and consumption tends to study and makes an empirical study on the influence of different construction methods on consumption types and the influence of different consumption tendencies on consumption types, which enriches the related research of physical purchase and experiential purchase.

Second, it reveals the influence of different construction methods on consumption types, which affects the explicit behavior and implicit psychology of the consumers. Experiment 2 proves that interdependent self-construal has a significantly higher degree of pleasure in experiential purchase than physical purchase because interdependent self-construal defines themselves by the relationship with others, they attach importance to the relationship with others, the core of their attention is to create a harmonious interpersonal relationship, and experiential purchase due to its social can meet the needs of interdependent self-construal of interpersonal relationships and can increase the intimacy between people. Independent self-construal is more likely to experience the immediate pleasure of physical purchases. Physical purchase is usually an individual behavior, which is relatively isolated. Independent self-construal perceives the difference between themselves and the outside world in the physical purchase and obtains more happiness.

Third, it enriches the research on materialism and consumption propensity. Researchers often suggest that materialism is a personality trait but ignore that experiential purchase propensity is also a personality trait that significantly affects the purchase behavior of consumers. This study verifies through experiments that although materialists attach importance to physical purchase, the physical purchase cannot bring the expected happiness, the experiential purchase can help materialists establish the relationships of family and friends, and the support of family and friends can promote the improvement of happiness.

It is also important to pay attention to consumer experience, the consumer experience as an important element of enterprise marketing strategy to manage, enterprise product form whether pure physical products, physical products with experience or experience products, consumers will produce use experience, consumer experience is good or bad affect the enterprise product sales. From the enterprise level, we should pay attention to consumer experience and have channels to collect and understand consumer product experience, pay attention to consumer experience feedback, and constantly improve the consumer experience. Pure physical products should increase the function or characteristics to stimulate consumer experience. Experience products should pay attention to the feelings brought to consumers in the experience process and constantly improve or upgrade experience to avoid the negative impact of repeated experience on consumers.

In addition, the personality traits of consumers are fully considered to incorporate advocacy and packaging strategies. Self-construal consumers tend to focus on the context of stimulus, and their motivation to consume is often concentrated on sharing and maintaining contact with others. They pay more attention to the social experience of products, so such consumer companies can strengthen the value of products to promote interpersonal relationships, i.e., presenting social scenes and slogans to stimulate audience awareness and recognition of products. The background rarely stimulates consumers with independent self-construal. They pay more attention to self-expression and possession of things. Their uniqueness should be highlighted in publicity and packaging for such consumer products and the significance of self-representation to consumers.

The experimental design method adopted in the study is to construct the consumption type through the literal description, which is not a real shopping scene. Participants only use literal reading to virtualize shopping choices. Therefore, different results may appear in the real consumption scene. Future research can be based on real consumption scenes and real consumption. As a personality trait, materialism has been paid much attention to and studied by the academic circle.

Finally, Howell et al. (2012) explored the psychological formation mechanism of consumers experiencing purchase intention from the reward mechanism, and more psychological mechanisms are worth studying. Nowadays, the lifestyle of "minimalism" is popular in many countries, abandoning the redundant material experience of the simple life. Consumers in many countries show the pursuit of material and fanaticism in the early stage of rapid development. With the continuation of wealth, the pursuit of material of consumers is gradually reduced, which shows that high materialism consumption tendency will transform to experiential purchase tendency. In contrast, as a personality trait, experiential purchase tendency has not been paid attention to; however, in reality, consumers of this type pay less attention to physical purchases and pay more attention to their inner self-feelings.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

AX was responsible for the questionnaire design of the article. LL, SL, LW, and WP were responsible for the data collection of the article and the writing of the article. All authors contributed to the article and approved the submitted version.

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