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Measurement of the robustness and sustainability of China's economic development based on the shock of the COVID-19 epidemic

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Abstract: The stability and sustainability of economic growth have always been a hot topic of concern in the academic and practical circles around the world. The purpose of this study is to examine the stability and sustainability of China's economic growth. For over 200 economies around the world, ensuring the stability and sustainability of their economic development in the face of sudden and catastrophic events is a great challenge. The COVID-19 epidemic in 2020 is just an emergency to test the economic development of each economy. The method adopted in this study is to observe the economic growth of more than 200 countries and regions in the world in 2020, visually measure the economic growth of each economy after being impacted by the COVID-19 epidemic, and then further explain the reason for the robustness of China's economic growth with the help of shock theory, statistical methods, including variance coefficient, nonlinear econometric model, shock entropy and other quantitative indicators. This study found that although the impact of the COVID-19 epidemic on China's economic growth is huge on the whole, the resilience of China's economic growth is significant, and the original trend of economic growth has not changed because of the impact of the COVID-19 epidemic. Its average variance coefficient is only 0.42, and the shock entropy is almost 0. The conclusion is that China's economic development is not only robust, but also sustainable. The practical significance of this study is that the perfect industrial economic structure and the Chinese style COVID-19 epidemic prevention and control model can still maintain the existing track of economic development at a certain cost of economic development, ensuring that the overall trend of economic growth remains strong, which lays a solid foundation for economic and social development after the COVID-19 epidemic.

Keywords: *COVID-19, Economic growth, Shock entropy, Shock theory, Sustainability.*

1. Introduction

"White lung disease" similar to COVID-19 infection symptoms has been prevalent in the United States and parts of Europe in July 2019 or earlier [1-4]. However, since the Director General of the World Health Organization Tan Desai announced in Geneva, Switzerland, on February 11, 2020 that the pneumonia infected by novel coronavirus was named "COVID-19", 2020 has been officially recognized as the "first year" of the COVID-19 epidemic. For the economic development of all countries in the world, the COVID-19 epidemic in 2020 is an emergency, testing the stability of social and economic development of all countries and regions, and a major issue related to the sustainable and healthy development of human beings. The experience and lessons learned from post event research in response to this sudden event not only have significant academic value, but also have practical significance. It even provides a significant and highly referenced action plan for human society to fight against similar catastrophic emergencies in the future, in maintaining social and economic stability and sustainable development.

Although there may be vastly different economic development models in various countries and regions around the world, the stability of these economic development models remains the most important issue worth studying. In just the past two decades or so, there have been multiple global events that have had varying degrees of shock on different economic development models, such as the SARS crisis in 2003,

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the subprime financial crisis in 2008, the debt crisis in 2013, and the trade friction between China and the United States between 2018 and 2019 [5]. The shock on various economies around the world is evident.

The outbreak of COVID-19 in 2019 was officially named COVID-19 by the World Health Organization at the beginning of 2020. COVID-19 became the pathogen that caused the worldwide COVID-19 epidemic in 2020, which had a great shock on world economic development. The COVID-19 epidemic has had a wide and far-reaching shock on the socio-economic system, including the negative shock on economic growth [6]. The COVID-19 epidemic has a negative shock on world economic growth by influencing commodity price fluctuations, such as energy and food price fluctuations. The economic growth of the most representative countries ranking in the top ten in the world in 2020 is negative in the United States, Japan, Germany, the United Kingdom, India, France, Italy, Canada and South Korea, except for China[1], whose economic growth is 2.2% [7]. If we look at the prevention and control of COVID-19 infection in China, the prevention and control model of COVID-19 epidemic2 in China has been vividly demonstrated in the practice of 2020. The prevention and control model of China's epidemic in 2021 and 2022 is basically the replication of the epidemic prevention and control model in 2020, which is the shock of COVID-19 epidemic on China's economic development in 2020, it is not the reason for the shock of COVID-19 epidemic on China's socio-economic development in 2021 or 2022. However, the COVID-19 epidemic has a significant shock on China's economic development [9], for example, prefecture level and county-level cities in Hebei Province are still struggling to restore their local economic development until the end of 2021 [10]. China's economic growth has been reduced due to the shock of the COVID-19 epidemic, but its prospects are optimistic [11]. COVID-19 affects China's economic growth rate (EGR) to 2.35% [12], The COVID-19 epidemic had a great shock on the GDP in the first quarter of 2020. The GDP growth dropped by more than 6% compared with the same period last year. Then from the second quarter to the fourth quarter, the GDP growth gradually recovered, and finally achieved positive growth in 2020 [13, 14]. Under the shock of the COVID-19 epidemic, although China's economic growth has been greatly shocked, the government has slowed down the speed and extent of economic growth decline through debt measures [15]. The reason why China's economic growth can still maintain positive growth under the shock of the severe COVID-19 epidemic is mainly determined by the characteristics of China's economic growth.

The government's economic policies have a significant positive shock on the maintenance of China's economic growth. The determinants of China's economic growth driven by the government's active policies are multidimensional. Economic growth aggregation is a path towards national prosperity driven by economic complexity, which can be measured by a multidimensional index that evaluates a country's export package combination [16]. The process of China's economic development has shifted from high-speed development to high-quality development, and from a factor driven stage to an innovation driven stage [17]. The path to promoting high-quality economic development has diversity, which mainly depends on the government's policy choices. Green development is a measure of high-quality economic development, and government environmental investment promotes green development [18], however, from a location perspective, the growth of GDP per unit in a region may not necessarily have a positive shock on the use of green patents as a measure of green development indicators [19], the integration network relationships between regions promote China's connotative economic growth, while the integration network relationships between regions promote China's connotative economic growth [20]. Improving the utilization efficiency of new energy is also one of the path choices for green development. To achieve long-term economic growth by accelerating the transformation of new energy, such as the development of renewable energy [21]. In order to promote economic growth, the demand for energy among people in low-income countries is increasing [22], this accelerates the increase in carbon

[1]Limited by the special arrangement of actual administrative planning and jurisdiction, the "China" mentioned in the whole article is only limited to 31 provinces and municipalities directly under the Central Government of Chinese Mainland, not including Hong Kong Special Administrative Region, Macao Special Administrative Region and Taiwan Province. The Hong Kong Special Administrative Region, Macao Special Administrative Region, and Taiwan Province are classified as other regions of the world in this article.

[2]Such as, nucleic acid testing or serum positive antibody testing and screening, widespread vaccination of novel coronavirus vaccine, development of emergency special drugs to treat novel coronavirus pneumonia infection, and strengthening physical epidemic prevention measures, such as wearing qualified masks, keeping enough safety distance between people, doing a good job of personal hygiene, doing a good job of isolation measures key monitoring of health code and big data [8], etc.

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emissions, thereby exacerbating abnormal climate change. Climate change has led to an increase in energy demand, with the United States, Europe, and China all experiencing an increase of over 25% in energy demand by 2050 [22]. Under the shock of COVID-19 epidemic, the structure of China's economic development situation is stable through Fourier approximation, which may be caused by the nonlinear causal relationship between China's economic development and environmental quality [23]. However, transitional economic growth will come at the cost of environmental degradation, resulting in an environmental Kuznets curve [24]. The government achieves high-quality economic growth through industrial agglomeration. Traditional experience has shown that an increase in carbon emissions is inevitable, and digital development can be used to achieve a balance between economic growth and carbon emissions, thus achieving high-quality economic development [25]. There is an obvious positive correlation between GDP growth and carbon emissions in the eastern, northern, central, and western regions [26]. The effective implementation of carbon neutrality strategy is an important way to achieve high-quality economic growth. To achieve carbon neutrality strategy, there are multiple technological paths to choose from, for example, improving carbon capture, utilization, and storage technologies [27]; Using new energy sources such as wind and solar to provide electricity for electrolytic hydrogen production to achieve zero emissions, although currently this technology may be constrained by land and water resources [28, 29]; The efficient utilization of small and medium-sized wind energy is the best way to break through the constraints of current land and water resources [30]; Optimizing the rural energy transformation model can achieve China's carbon neutrality strategic goals [31] and so on.

In the prevention and control of COVID-19, China adopts a closed isolation prevention and control model, while other countries or regions in the world adopt a semi closed prevention and control model. The differences in prevention and control modes have led to the different epidemic patterns of COVID-19 in China in 2020, 2021 and 2022 from those in other countries or regions in the world. According to the moving average data released by the seven day surveillance from February 2, 2020 to February 2, 2022 in the United States, COVID-19 infection cases reached a peak on February 2, 2022 [32], this is very different from the epidemic situation in China. The COVID-19 infection cases in China are mainly concentrated in 2020, and more than 80% cases are concentrated in Hubei Province, especially in Wuhan and its surrounding areas [8]. The huge differences in the prevention and control of the COVID-19 epidemic between China and the United States are mainly due to the different perceptions of the COVID-19 epidemic between China and the United States, which further affects the spatial-temporal differences in the shock of economic growth between China and the United States. China's GDP growth rate in 2020 is positive, while the United States' GDP growth rate in 2020 is negative. China's manufacturing PMI was shocked by the COVID-19 epidemic in April 2020, which had a significant decline, but then recovered to the basic situation before the epidemic. The situation in the United States and the European Union was volatile and very unstable [10]. The manufacturing industry is the main factor determining the secondary industry, which is the fundamental support for China's economic growth. This determines the resilience and stability of China's economic growth, and is also the determining force for the sustainability of economic growth. In fact, the European debt crisis around January 2010, the US China trade war in April 2018, and the conflict between Russia and Ukraine in February 2022 did not have a significant shock on China's Manufacturing Purchasing Managers Index, but the shock on the Manufacturing Purchasing Managers Index in the United States and the European Union was significant [33]. This reflects that the resilience of China's economic development is strong enough.

The isolation and isolation measures in China's closed environment are objectively not considered positive measures for economic development, but relatively negative. Under such strict epidemic prevention and control, and through the description of China's economic instability index, it is found that the COVID-19 epidemic is the largest shock on economic growth among various crises in the past two decades. This shock is transmitted to the level of macroeconomic growth through the decline of consumption, investment and exports [5], it may even cause a long-term economic recession, but China's GDP growth rate can still be maintained above zero. In contrast, the GDP growth rate of the vast majority of countries or regions in the world is basically negative, highlighting the resilience of China's economic development. Nevertheless, the shock of the COVID-19 epidemic on China's economic development in 2020 is still considerable and cannot be ignored, as shown in the figure below.

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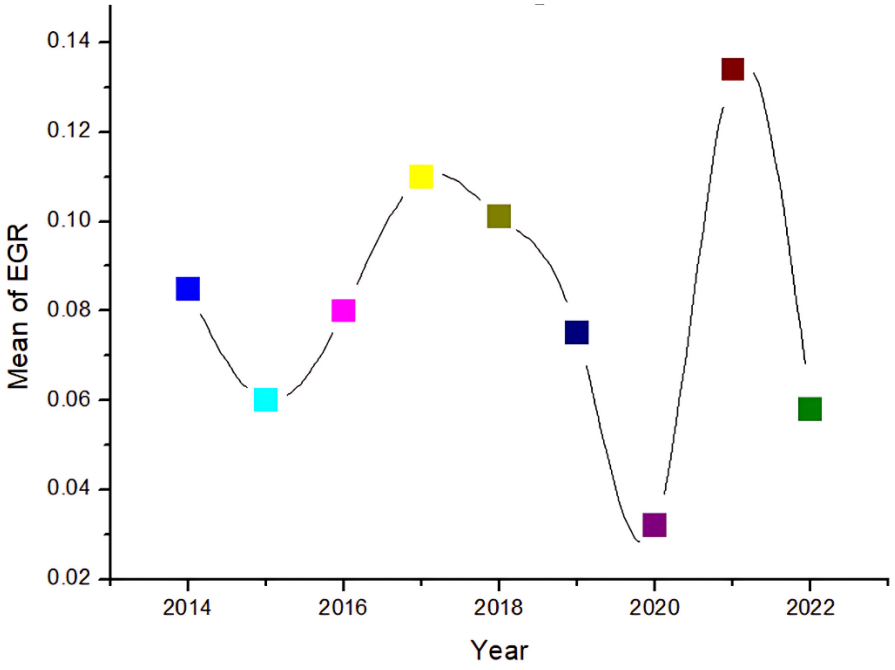

Figure 1.
The shock of COVID-19 epidemic on China's economic development in 2020.
Source: Calculated based on data from the website of the National Bureau of Statistics.

As can be seen from Figure 1, the COVID-19 epidemic in 2020 had a significant shock on the economic growth of that year, and the economic growth in 2021 was a natural return from the economic development in 2020 shocked by the COVID-19 epidemic in that year. In fact, according to the prevention and control of COVID-19 epidemic in 31 provinces and municipalities directly under the Central Government of China (PMDCGC), the prevention and control of COVID-19 epidemic in 2021 and 2022 are steady, and the increase in the diagnosis of COVID-19 infection is very limited. The shock of the epidemic on the economic development of that year is mainly due to the inertia of COVID-19 epidemic on the economic shock in 2020.

According to the economic growth of 31 PMDCGC from 2014 to 2022, whether it is the natural fluctuation of the economic growth level before the outbreak of COVID-19, or the huge shock of COVID-19 on the economic growth level in 2020, and the economic development in 2021 and 2022 affected by this shock, the economic development of 31 PMDCGC is stable and sustainable. This shows that China's economic development model has a very strong resilience in economic growth and an outstanding ability to combat risks under the shock of the sudden COVID-19 epidemic.

Why does China's economic development model have such economic growth resilience? The resilience of China's economic growth depends on the high-quality development of the Chinese economy, rather than the quantity of China's economic growth that is widely perceived by people [34]. In fact, it can be seen from some economic and social development data indicators in 2020 released by the Chinese government on February 28, 2021, although the shock of COVID-19 epidemic on social economy in 2020 is extremely serious.

The measurement indicators for economic development in this article refer to the EGR, which refers to the growth rate of Gross Domestic Product (GDP). From a global perspective, not all countries have detailed economic and social statistical data that can be used to evaluate their economic development. It is not very realistic to use algorithms and satellite scanning images to accurately predict or evaluate the economic development status of a region in the absence of real data. However, the use of human-machine coordinated deep neural network models, which utilize satellite image grids, can compensate for these

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shortcomings and achieve the best choice for remote sensing measurement of economic development status [35]. This economic development assessment method, such as in the face of various huge disasters such as the COVID-19 pneumonia epidemic, is one of the best emergency measures when traditional statistical methods cannot be carried out due to special difficulties, and is also an effective supplementary means to verify the objectivity of conventional statistical data from a macro perspective.

The stability of economic development refers to the stickiness of economic development remaining strong in the face of sudden social or economic events, without any sudden changes or fractures from direct to downward. Under the shock of emergencies, the level of economic development may experience brief fluctuations, but its overall development trend is not fundamentally different from the overall trend before the shock of emergencies.

Sustainability of economic development refers to the relative stability of economic growth in adjacent years, without any tearing or rupture, the compactness of its development path, the directionality of its development direction, and the basic stability of its overall development trend. Even under the shock of unexpected events, this basic situation still lacks qualitative fluctuations and maintains the stability of its original direction and basic situation.

The arrangement of the remaining article content is as follows: the second part is the main results, the third part is the discussion of the results, the fourth part is the methods, data included, and the fifth part is conclusion.

2. Main Results

2.1. Shock Theory

Regarding shock theory, this is a relatively inclusive scientific category, for example, the impact of one event on another belongs to the category of mild shock; The impact of one disaster event on another highly correlated event belongs to the category of severe shock, etc. Almost all relationships between events can be explained using shock theory. Shock theory is a scientific theory that studies the mutual influence between correlated events in a statistical sense. Related events are events with certain relationships, which may have direct causal relationships, indirect causal relationships, or only some kind of correlation. Regardless of the type of relationship, there is a common characteristic, which is the existence of bidirectional or unidirectional influences between events.

Assuming X is the matrix of unexpected events and Y is the matrix of correlated events shocked by X, then

$$\mathrm{Y} = \mathrm{f}(\mathrm{X}(\mathrm{t})) + \varepsilon \mathrm{t} \qquad (1)$$

the shockmetric model (1) called Y about X, where f is a differentiable function, ε is a matrix of random perturbation terms, t is time, where,

$$\mathrm{Y} = \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_k \end{pmatrix}, \mathrm{f}(\mathrm{X}(\mathrm{t})) = \begin{bmatrix} a_{1,1}, a_{1,2}, \cdots, a_{1,m} \\ a_{2,1}, a_{2,2}, \cdots, a_{2,m} \\ \vdots \\ a_{k,1}, a_{k,2}, \cdots, a_{k,m} \end{bmatrix} \begin{pmatrix} f_1(x_1(t)) \\ f_2(x_2(t)) \\ \vdots \\ f_m(x_m(t)) \end{pmatrix},$$

$$\varepsilon = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_k \end{pmatrix}, \quad \varepsilon_j \sim N(0,1), j = 1,2,\cdots,k, \mathrm{k} = 1,2,\cdots; \mathrm{m} = 1,2,\cdots,$$

$a_{j,i}$ is a constant, $i = 1,2,\cdots,m.$

If ε follows the standard normal distribution in the sense of matrix or shortly the standard normal distribution, i.e. $\varepsilon \sim \mathrm{N}(0, \mathrm{I})$ means that Y has been effectively shocked by X in a statistically significant sense, where O is the zero matrix and I is the identity matrix.

Lemma: If the shock of even matrix $\mathrm{X_i}$ on Y is effective for any $\mathrm{i}=1,2,\cdots,\mathrm{p}$, and if $\overline{\mathrm{X}}$ exists, then Y is effectively shocked by $\overline{\mathrm{X}}$,where

$\overline{\mathrm{X}}=\frac{\mathrm{X_1}+\mathrm{X_2}+\cdots+\mathrm{X_p}}{\mathrm{p}}$, for any positive integer p.

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The shock effect depends on the strength of X's statistical explanatory power for Y, that is, the stronger the statistical explanatory power of X for Y, the more significant the shock effect of X on Y. On the contrary, if X has weak statistical explanatory power for Y, then the shock of X on Y can be ignored. If ε does not follow the standard normal distribution, it is statistically invalid to say that Y has been shocked by X. According to the definition, ineffective shock does not mean harmless shock. In the case of ineffective shock, the harmfulness of the shock may still occur, so this type of shock is isolated and has no risk of overflow. Of course, if there are a large number of harmful isolated shocks under certain conditions, these shocks may evolve into statistically significant effective shocks. For this, we have obtained the following theorem and corollaries:

Shock Theorem: If the shock of event matrix X on event matrix Y is statistically significant, then the shock of X on Y is effective.

Corollary 1: If the shock of event matrix X on event matrix Y is invalid, then the shock of X on Y is small-scale.

Corollary 2: Any sudden hot event or event matrix that has an effective shock on different socio-economic systems, only when this sudden event or event matrix forms an spillover scale effect.

If an event matrix X is composed of one element, then the event matrix X is simply referred to as event X.

"**Spillover scale effect**" refers to the situation where an event's shock on the external environment reaches a sufficient scale, and the spillover of the event's shock has become an uncontrollable development trend.

When t is continuous, the sensitivity of X to Y shocks can be described by the following stochastic differential equation:

$$\frac{dY}{dt} = f'(X(t))\frac{dX(t)}{dt} + \varepsilon, \qquad (2)$$

when t is discrete, the sensitivity of X to Y's shock can be described by the following stochastic difference equation:

$$\frac{\Delta Y}{\Delta t} = f'(X(t))\frac{\Delta X(t)}{\Delta t} + \varepsilon, \qquad (3)$$

the function f is differentiable. Model (1) is suitable for describing macroscopic phenomena, while Model (2) or Model (3) is more suitable for describing microscopic phenomena. This article studies macroeconomic phenomena, and the applicable model is Model (1).

Property 1 : If A is a constant matrix and Y is an event matrix, then the shock of A on Y is trivial, that is, the change in the impact of A on Y is zero.

Property 2 : If the shock of event matrix X on event matrix Y is effective, then AX is also effective for Y, where A is a non-zero constant matrix.

Property 3 : If the shock of event matrix X_1 and event matrix X_2 on event matrix Y is effective respectively, then the effective combination of event matrix $aX_1 + bX_2$ is also effective for the shock on Y, where a and b are arbitrary constants matrix and not all equal to zero matrix.

Shock Time Theorem: If the shock of event matrix X on event matrix Y is effective, then the time to maintain this effective state of shock is equal to the time that X continues to experience utility.

Shock Marginal Attenuation Theorem: If the shock of event matrix X on event matrix Y is effective, then the scale diffusion rate of this shock spillover decays with the extension of time to maintain the effectiveness of this shock.

If the shock of event X on event Y forms an shock system {(X, Y)}, the indicator describing the complexity of this system is called **shock entropy (SE)**, defined by,

$$SE=-P(X,Y)\log_2 P(X,Y), \qquad (4)$$

where P(X) is the probobility of event X.

According to (4), the larger the **SE**, the more complex the shock system is; The smaller the **SE**, the simpler the shock system. The shock of COVID-19 epidemic on China's GDP growth in 2020 constitutes a simple shock system, through measurement and statistical analysis, the **SE** is about 1.09×10^{-6} bit.

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This shows that the shock of the COVID-19 epidemic on China's economic development in 2020 is generally mild, and it has not broken the existing trend of its economic growth.

2.2. Characteristics of Prevention and Control of COVID-19 Pneumonia in China and its Shock on Economic Growth

At the beginning of 2020, the epidemic of COVID-19 confirmed by the World Health Organization will undoubtedly have a tremendous, even catastrophic, shock on the social and economic systems of countries and regions around the world. However, in terms of the targeted prevention and control measures taken by countries and regions around the world during the epidemic and their effects, we can roughly divide the Chinese model and the world model into two models for the prevention and control of COVID-19 epidemic.

The Chinese model refers to the COVID-19 epidemic prevention and control model covering 31 PMDCGC, excluding those outside Hong Kong Special Administrative Region of China, Macao Special Administrative Region of China and Taiwan Province of China. It is characterized by that more than 80% of COVID-19 infection cases are mainly concentrated in Hubei Province, and less than 20% of COVID-19 infection cases are scattered in other 30 PMDCGC, This has formed the temporal and spatial distribution trend map of the epidemic situation of COVID-19 in China, referred to as the spatio-temporal trend. This spatio-temporal trend determines the trend of China's economic development in 2020. Compared with the GDP growth rate in 2019, under the shock of the COVID-19 epidemic, the GDP growth rate in 2020 dropped by about 4%, until it maintained a GDP growth rate of no less than 2%, forming the most depressed scenario of the whole social and economic development in more than 40 years.

The world model refers to the COVID-19 epidemic prevention and control model of more than 200 countries and regions in the world, excluding the Chinese model. As we all know, it has a common feature, that is, every local COVID-19 epidemic prevention and control has at least one open window in a certain time and space, that is, a window allowing the free flow of people and materials inside and outside the region. As a result, the distribution of COVID-19 infection cases around the country is relatively uniform, and some cases are even completely open to pursue the whole society's prevention and control effect of full immunity. One of the direct consequences of the characteristics of the world model is that every place in the world covered by the world model, including countries and regions, has a basically negative GDP growth rate in most countries and regions in 2020.

The division between the Chinese model and the world model has its theoretical basis. The Shock Theorem and its corollaries mentioned above are the theoretical basis for the division of the epidemic prevention and control model of COVID-19. The Shock Theorem and its corollaries describe shock theory, which is the theory of the shock of one event or event matrix on another event or event matrix. The distribution of GDP growth rates in countries around the world in 2020 is as follows:

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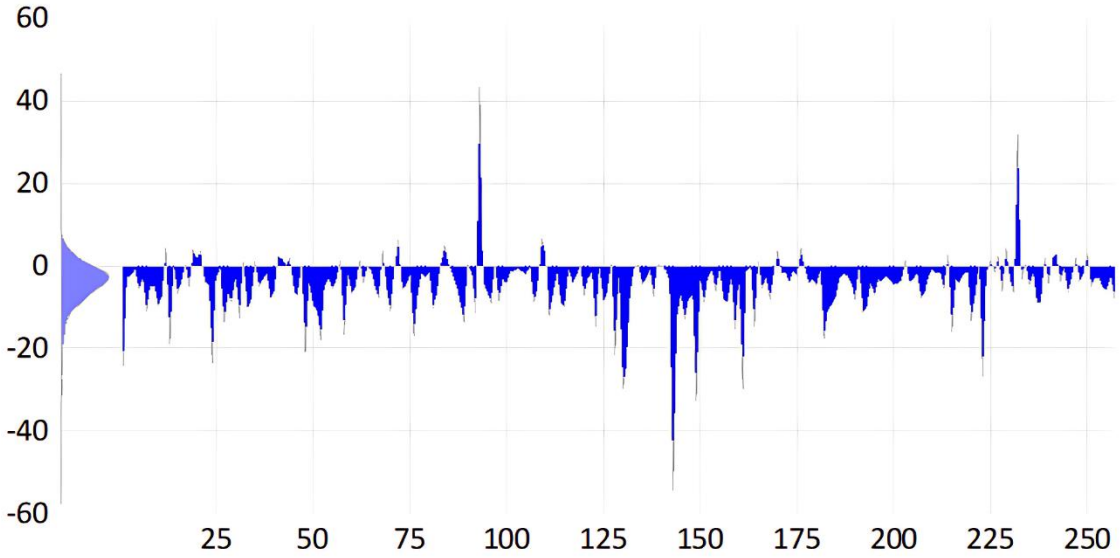

Figure 2.
Distribution of GDP annual growth rates (%) in over 200 countries and regions in 2020.
Sources: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

According to Figure 2, which is the data provided by World Development Indicators, only 15.56% of countries or/and regions have a positive GDP growth rate, and China is the only major country with a positive GDP growth rate. The remaining 84.44% of countries or/and regions, including all major and powerful countries outside of China, have negative GDP growth rates. The distribution density map on the left shows that its distribution follows a normal distribution. In 2020, whether the GDP growth rate is positive or negative, the GDP growth rate of countries or regions with large growth fluctuations is a small probability event, and the GDP growth rate of most countries or regions is presented in a large probability distribution area, indicating that the impact of the COVID-19 epidemic on the economic development of the whole world in 2020 is a large probability event, which is an unavoidable practical disaster.

2.3. Based on the Relationship Between the Digital Economy and the Traditional Economy Under the COVID-19 Epidemic Situation - the Traditional Economic Development Model Dominates

Although the COVID-19 epidemic has had a huge shock on the socio-economic systems of countries and regions around the world, through the description of China's economic instability index, it is found that the COVID-19 epidemic has the largest shock on economic growth among various crises in the past two decades, and this shock is transmitted to the macroeconomic growth level through the decline of consumption, investment and exports [5]. However, high-quality economic development has a significant inhibitory effect on the prevalence of COVID-19.

With the GDP growth rate in 2020 as the observation index, the GDP of almost 200 countries and regions around the world has experienced extremely serious negative growth, which indicates that the COVID-19 epidemic has caused devastating damage to the world's socio-economic system.

In fact, the improvement of the level of economic development is of positive and positive significance for the prevention and control of epidemic diseases such as COVID-19 pneumonia.

From the regression analysis report below, we can see that the shock of COVID-19 epidemic on China's economic development is statistically significant. What we are interested in now is that although the COVID-19 epidemic has a huge shock on China's economic development, how destructive is the shock? Can it affect the stability and sustainability of China's economic development?

Our answer in this article is that although the shock of the COVID-19 epidemic on China's economic development cannot be ignored, its negative shock is short-lived and cannot change the stability and sustainability of China's economic development.

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The traditional economic development model still dominates the development of China's economy, and the digital economy development model characterized by digital technology is still in an auxiliary position. Its role in overall economic development is still very limited, although in the past two decades, non-contact economic activities such as electronic payments have been flourishing in China. Based on the historical experience of the integration and transformation of social development models, it is still a long and arduous social and economic development strategy for the digital economy to occupy the leading position in China's economic development.

The digital economy refers to a new economic discipline that optimizes the allocation of social and economic resources driven by digital technology. This is an inevitable trend for the development of traditional economics towards 21st century economics. At present, the digital economy still belongs to the digital application part of traditional economics and has not yet formed a new independent discipline of economics. In fact, the digital economy defined in the "*Statistical Classification of Digital Economy and Its Core Industries (2021)*" compiled by the National Bureau of Statistics of China is "a series of economic activities that use data resources as key production factors, modern information networks as important carriers, and the effective use of information and communication technology as an important driving force for efficiency improvement and economic structure optimization." This is a practical economic activity based on traditional economic theory and using modern science and technology as operational means, and also belongs to the electronic application category of traditional economy. The digital economy, which optimizes various resource allocation through digital technology, will develop and mature at an unprecedented speed.

Therefore, we have every reason to believe that, as the digital economic development model replaces the traditional economic development model, when a social emergency such as the COVID-19 epidemic occurs, the socio-economic development will not be seriously affected as the economic development in 2020, that is, the economic growth of almost most countries and regions in the world presents a crisis situation of negative growth, but will certainly present a positive, stable, sustainable and stable socio-economic development trend.

The human resources that have been most affected by the epidemic, human capital is a key element of economic growth. The digitalization of the social economy has significantly affected the aggregation and gap of human capital between urban and rural areas, resulting in the Matthew effect [36]. However, China's economic growth model still follows the traditional development model, and the shock of digitalization is still extremely limited [8]. In fact, human capital, fundamentally speaking, is still relatively weak under the influence of digitalization, although the complete and sufficient digitalization process of human capital is an inevitable trend in social and economic development.

2.4. The Scale Spillover Effect Formed by Sudden Hot Events is Actually the "Butterfly Effect" in Chaotic Systems

The COVID-19 epidemic in 2020 is the "butterfly effect" that led to the chaos of social and economic development around the world at that time. This "butterfly effect", which has caused social and economic chaos in the world, has lasted for more than a year and is a huge disaster faced by human society in the early 21st century. Overall, this "butterfly effect" has caused significant negative effects on the existing socio-economic order of the entire world. Activities centered around "people" such as life, work, and learning have been unprecedentedly suppressed, exacerbating the difficulties and cost burden of human survival. Under normal circumstances, the government increases public service spending [37], for example, increasing capital medical expenditure will help economic growth, but during the COVID-19 epidemic, medical expenditure cannot significantly promote economic growth, and excessive medical expenditure will harm economic growth [38]. Human health capital, such as personal health expenditure, government health expenditure, and social service expenditure, has a non-linear effect on economic growth [39]. Compared with the temporal and spatial trend of COVID-19 epidemic in more than 200 countries and regions in the world, China's socio-economic development is the "lucky one" of the "butterfly effect", that is, more than 80% of COVID-19 infection cases are concentrated in Hubei Province, while less than 20% of COVID-19 infection cases are distributed in other regions of the country. The spatial-temporal distribution of the epidemic of COVID-19 obviously weakens the destructive power of this "butterfly effect" on China's socio-economic order. Although the infection of COVID-19 in China is

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not as serious as people think, the introduction of fuzzy mathematical models to predict that China's economy will recover to the level before the COVID-19 epidemic probably needs about one year after the end of the epidemic. The basis is to analyze the eight factors that affect economic growth, namely, consumer price index, final consumption of residents, employed population, fiscal revenue, imports, exports, final government expenditure and money supply [40]. Especially for the employed population, the demographic dividend of labor and education has a significant positive explanatory power on economic growth [41].

2.5. System Robustness of GDP Growth

The robustness of China's economic growth comes from its systematic maintenance power. Through the measurement of the coefficient of variance, the average coefficient of variance of China's GDP growth rate from 2016 to 2022 was 0.42, indicating that the systematic stability of its economic growth is obvious. If the impact of the COVID-19 epidemic on economic development in 2020 were removed, the average value of the variance coefficient of China's GDP growth rate would be lower.

3. Discussion of the Results

3.1. Discussion on the Application of Theorems and Their Corallaries

For the convenience of discussing the model, we only consider the case of k=1 and t=2020. As for the situation where k>1 and t≠2020, a similar analysis can also be conducted, but its presentation may be more complex.

According to Corallary 1, an ancient saying can be explained: "If a lie is told a hundred times, it becomes truth". That is to say, in social public opinion management, if a lie is repeatedly spread on a large scale, the audience who accepts the lie without knowing the truth will naively believe that this "lie" is actually the real situation and an objective expression of the real event. From this, it can be seen that the biases that different social groups have towards other social groups are basically the result of the large-scale repeated brainwashing of their social communication systems.

Therefore, the reason why "lies=truth" is believed to be true by people is because the audience repeatedly receives the shock of this argument until they finally accept it. On the contrary, the reason why "lie ≠ truth" is often rejected by people is because a large number of opposing arguments shock the audience, causing people to have the wrong illusion that "lie ≠ truth" is wrong. To dispel the many fallacies of conspiracy theory in the public opinion field, it is only possible to create a fair, open, and transparent new media that is impartial and unrelated to any interest group.

Corollary 2 suggests that any hot spot emergency, without the formation of scale spillover, can only have a certain shock on its associated isolated systems at most. Of course, so-called "isolated systems" are relative. In fact, all systems are interrelated, while "isolated systems" have a low degree of correlation with other related systems and cannot have a significant shock on them. In the field of social sciences, the channels for the existence of "isolated systems" are not only caused by natural information blockage, but also by the so-called "conspiracy theory" of the dominant party in information dissemination blockading, blocking, or being occupied by highly targeted false information.

The shock of the COVID-19 epidemic in 2020 on China's socio-economic system cannot but be said to be huge [12], however, as far as China's socio-economic system is concerned, this shock effect is still partial. China's economic growth has been reduced due to the shock of the COVID-19 epidemic, but its prospects are optimistic [11]. According to the epidemic situation of COVID-19 in 31 PMDCGC, more than 80% of COVID-19 infection cases occur in Hubei Province, especially in Wuhan and its surrounding areas. The total number of cases of COVID-19 infection in the remaining 30 PMDCGC is less than 20%, which is basically scattered throughout the country. This situation reflects that the prevention and control measures taken by the Chinese government during the epidemic of COVID-19 have created an ideal spatio-temporal trend of the epidemic compared with that of 30 PMDCGC outside Hubei Province. Hubei Province has become an "isolated island" of the epidemic of COVID-19, which is exactly the situation implied by Corollary 2. The "isolated island" effect of the epidemic prevention and control has also become a blocking band for the "butterfly effect" of COVID-19 infection, which is difficult to form a flood trend, reflecting that the Chinese government's COVID-19 epidemic prevention and control measures are

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extremely powerful and effective. Therefore, the "shock" of the COVID-19 epidemic on China's social and economic aspects is relatively mild, and it has not severely damaged the foundation of China's social and economic system, which is why, in the world, only China's GDP growth rate in 2020 is positive among the world's major countries.

In fact, the epidemic situation of COVID-19 in more than 200 countries and regions in the world other than China is in line with the situation described in Corollary 2. These countries and regions are faced with a huge shock of COVID-19 epidemic situation, and their corresponding socio-economic systems have suffered extremely serious damage. Some countries, such as Argentina, have even suffered a devastating blow.

From the perspective of **SE**, the shock of COVID-19 epidemic on China's economic development is not as big as expected. In the shock system：

{(confirmed number of people infected with COVID-19 pneumonia, GDP)},

composed of COVID-19 and economic development, its **SE** can well measure the complexity of this system. The greater the **SE**, the more complex the system is, and the greater the shock of the COVID-19 epidemic on economic development; The smaller the **SE**, the simpler the system will be, and the smaller the shock of COVID-19 epidemic on economic development will be. The actual situation of China in 2020, that is, the **SE** is almost zero, proves that the shock of COVID-19 epidemic on China's economic development in 2020 is very limited, which further confirms that the stability and sustainability of China's economic development is a very stable development trend.

3.2. Structural Characteristics of COVID-19's Shock on China's Socio-Economic Development

In 2020, the ratio of the GDP of Hubei Province to the sum of the GDP of the other 30 PMDCGC will be 4.45%. However, the number of COVID-19 infected people in Hubei Province in 2020 will account for more than 80% of the total number of COVID-19 infected people in 31 PMDCGC. This fact well explains the characteristics of the prevention and control of the Chinese COVID-19 epidemic, as well as the reasons for the resilience and sustainability of China's economic growth, that is, the shock of COVID-19 epidemic on China's economic development has not spread from Hubei Province to the other 30 PMDCGC, forming a large-scale shock spillover effect. This shows that China's economic development as a whole has not been hit by the COVID-19 epidemic and stagnated, although the shock is not small. This ensures the stability and sustainability of China's economic growth. The manufacturing industry is the main factor determining the secondary industry, which is a strong foundation for China's economic growth. This determines the resilience and stability of China's economic growth, and is also the determining force for the sustainability of economic growth

In fact, the European debt crisis in January 2010, the trade war between China and the United States in April 2018, and the conflict between Russia and Ukraine in February 2022 did not have a significant shock on China's Manufacturing Purchasing Managers Index. However, the shock on the Manufacturing Purchasing Managers Index in the United States and the European Union was significant [33]. The industrial structure is closely related to the employment structure, which is sticky and has a significant positive effect on economic growth. Economic growth has a positive shock on the employment structure [42]. This shows that although the COVID-19 epidemic in 2020 will have a huge shock on China's economic growth, it will not damage the long-term stability of its economic growth.

3.3. Interpretation of the "Butterfly Effect" of the Shock of COVID-19 Pneumonia Epidemic

According to the analysis of Chinese style epidemic prevention and control, the "butterfly" of the COVID-19 epidemic did not lead to a substantial "butterfly effect" in China, causing a devastating shock on the real economy, but relatively gently created an orderly "stagnation" of some socio-economic activities. It is not that this "butterfly" particularly likes China and is lenient in disrupting China's socio-economic order, but rather that the Chinese style epidemic prevention and control model has successfully suppressed the disturbance of this "butterfly" and greatly reduced its degree of harm to China's socio-economic development.

For countries and regions in the world outside Chinese Mainland, the COVID-19 epidemic determined in 2020 is the "butterfly effect" that ravages the social and economic systems of countries and

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regions around the world. This "butterfly effect" is not caused by the fact that the world's socio-economic system is in a natural "chaos" state, but by the lack of awareness of COVID-19 and the illusory governance concept of COVID-19 pneumonia, that is, the man-made "chaotic socio-economic system", which has led to COVID-19 ravaging the world's people and socio-economic system for three years, This is an extremely profound lesson for the world!

The "chaotic social and economic system" mainly relies on the results of the relevant mainstream media's overwhelming "brainwashing" of the public with the theme of artificially weakening the harm of "COVID-19", and gradually forms a relatively open social system composed of people and the so-called "harmless COVID-19". According to the theorems and corollaries, we know how the "butterfly" of "COVID-19" gently flapped its wings in such an open system, which resulted in the turbulent disaster scene of the "vast ocean" of the world. The theorems and corollaries also tell us how to effectively avoid these "disasters" that should not exist.

3.4. The Traditional Economic Growth Model Remains the Dominant Model for Promoting China's Economic Growth

The dominant mode of China's economic growth is still the traditional economic growth model. The current level of digitalization in China's economic development is still very low[3], even though China's economic and social activities that use electronic payments with digital characteristics have a history of 20 years. In the composition of the entire GDP, the part classified as digital is divided into 5 major categories, 32 medium categories, and 156 sub categories according to the "Statistical Classification of Digital Economy and Its Core Industries (2021)" released by the National Bureau of Statistics[4], which is consistent with the "2017 National Economic Industry Classification Annotation". This classification can be summarized into two categories, namely the digital industrialization part and the industrial digitization part. However, the relevant digital economy statistics have not been fully released yet. This indicates that the current economy is still dominated by traditional economic models. The following analysis also confirms this from an empirical perspective. The increase in the number of people diagnosed with COVID-19 pneumonia has an unavoidable shock on economic growth, because China's economic growth is still following the traditional path of economic growth, and has not been significantly shocked or affected by China's increasingly popular electronic payment or digital financial behavior (DFB) in the past two decades. This can also be verified from the positive correlation between digital financial behavior and the number of confirmed cases of COVID-19 [8]. In fact, there is no statistically significant positive correlation between China's digital finance behavior and its EGR. At present, digital finance behavior has a statistically insignificant negative effect on EGR, and the relationship is complex, indicating that the shock of digital finance on China's economic development is still superficial, it has not yet had an inherent shock on the development of the Chinese economy in terms of economic structure. Based on our data analysis, it has been found that there is a fourth-order polynomial econometric relationship between digital financial behavior and EGR, namely,

$$\mathrm{EGR} = a_0 + a_1 DFB + a_2 DFB^2 + a_3 DFB^3 + a_4 DFB^4 + \varepsilon, \qquad (5)$$

where $a_i, \mathrm{i} = 0, 1, 2, 3, 4,$ is a constant parameter, ε Is a random perturbation term. Empirical analysis has found that these relationships do not have statistically significant relationships, although the nature of the relationship between EGR and DFB is clear. The specific regression analysis is in the following, see Figure3:

[3] The digitalization of economic development, also known as the digital economy, is mainly reflected in the digital carriers of traditional economy, such as the application of digital technology in the service industry, which has not yet reached the stage of digital development of economic entities. At present, it is still in the initial stage of digitalization of economic entities, and the digital carrier of economic development is the main feature of the current digital economy, which is mainly reflected in the application level and belongs to the scope of management. As long as physical output digitizes, the digital economy is truly entering a new journey of mature development.

[4] The relevant files and data come from https://www.stats.gov.cn

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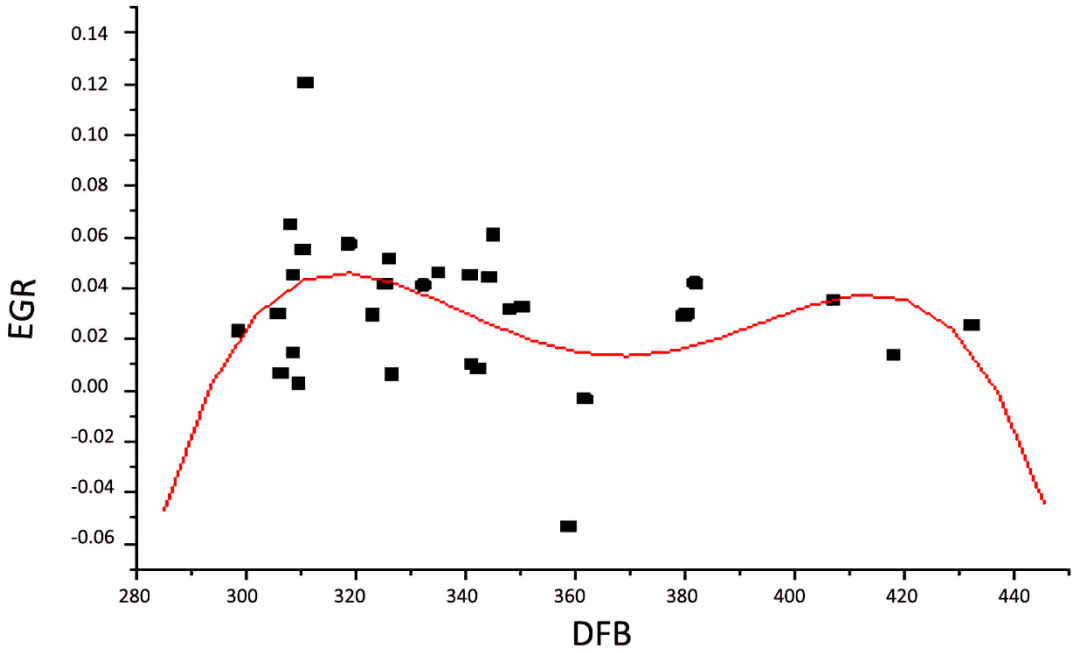

Figure 3.
Fourth order polynomial regression model for EGR and DFB.

and the regression report of Model (5) is as follows:

$$\widehat{EGR} = -90.236 + 1.004\text{DFB} - 0.0042DFB^2 + 7.62 \times 10^{-6}DFB^3 + 5.2 \times 10^{-9}DFB^4$$

$$(60.12) \quad (0.671) \quad (0.0028) \quad (5.15\times 10^{-6}) \quad (3.54\times 10^{-9})$$

$$R^2 = 0.1393 \quad \text{SD} = 0.02867 \quad \text{n} = 31 \quad \text{P} = 0.39986$$

The above empirical evidence indicates that the digital financial behavior, especially electronic payment behavior, which has the most extensive social practice foundation after 20 years, has not evolved into the digital economic model of China's socio-economic development. The shock of digital financial behavior defined by the digital inclusive financial index [43] on all levels of China's social economy is still very limited, and it has not yet developed into a basic model that can support social and economic development, although this digital financial behavior has a positive exponential relationship with the number of people infected with COVID-19 [8]. This shows that the significant shock of the COVID-19 epidemic on economic development stems from whether China's economic structure is dominated by the traditional economic structure, rather than from the digital economy that is developing in recent years, although the scale of the digital economy is gradually expanding.

3.5. Statistical Analysis of the Stability and Sustainability of China's Economy

Although the prevalence of COVID-19 has almost led to negative economic growth in most countries and regions in the world, China's economic development has not. COVID-19 epidemic has a long-term negative shock on China's economic growth [44]. Using linear correspondence theory to predict the recovery and growth of the economic system after being shocked by input-output sensitivity [45]. The main reasons for the long-term sluggish economic growth are the slowdown of capital deepening, the weakening of population dividends, and technological decline [46]. In fact, China's capital deepening adjustment is accelerating, and the dividend of population quality is strong. Technological progress, especially artificial intelligence (AI) and quantum technology, is accelerating technological innovation. The fact that these comprehensive factors are occurring and strengthening strongly supports the sustainability of China's economic growth. According to our empirical research, the shock of COVID-19 epidemic on China's economic growth is very limited. The shock of the COVID-19 epidemic on China's economic growth is short-lived, and this negative shock will not spread to the financial crisis [47]. In

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terms of agriculture, China will ensure self-sufficiency in the production of its main crops such as corn by 2030 by optimizing the existing cultivated land planting area [48]. Considering the relative completeness of China's economic system, its development stability and sustainability are relatively resilient.

For this reason, the following is to test whether China's economic development will have significant heterogeneity due to the shock of the COVID-19 epidemic?

Overall, the changes in EGRs of 31 PMDCGC from 2014 to 2022.

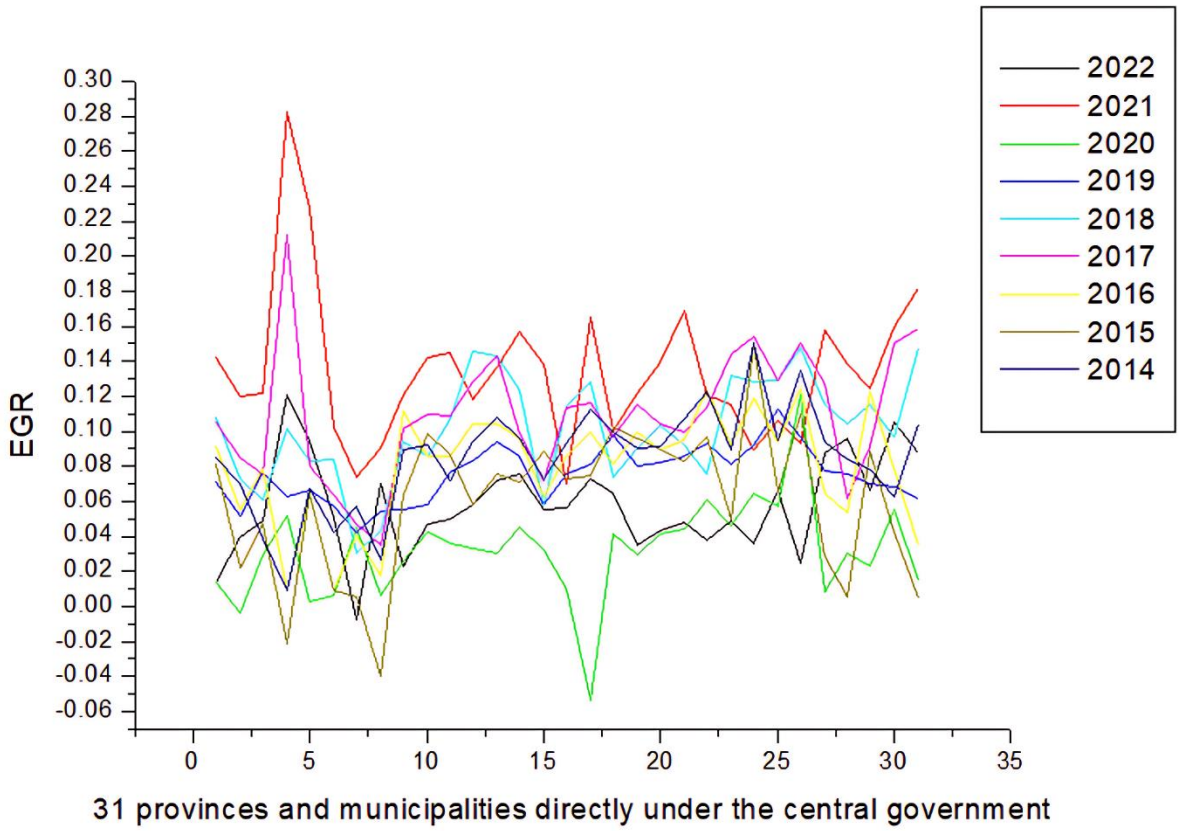

Figure 4.
EGRs of 31 PMDCGC from 2014 to 2022.
Sources: Data from https://www.stats.gov.cn

According to Figure 4, the EGR in 2021 fluctuated greatly, because the COVID-19 epidemic in 2020 had a great shock on the economic development in 2020, resulting in great fluctuations in the economic development level of 31 PMDCGC, which would affect the corresponding EGR fluctuations in 2021. It can be seen intuitively that before 2020, the EGR s of 31 PMDCGC showed a relatively stable distribution trend, indicating that the overall development status of the economy was stable. In 2020 and later years, the EGR had fluctuated greatly, mainly due to the shock of the global COVID-19 pneumonia epidemic. We can have a clear understanding of the frequency distribution of EGRs in 31 PMDCGC from 2014 to 2022, as shown in the following Figure 5:

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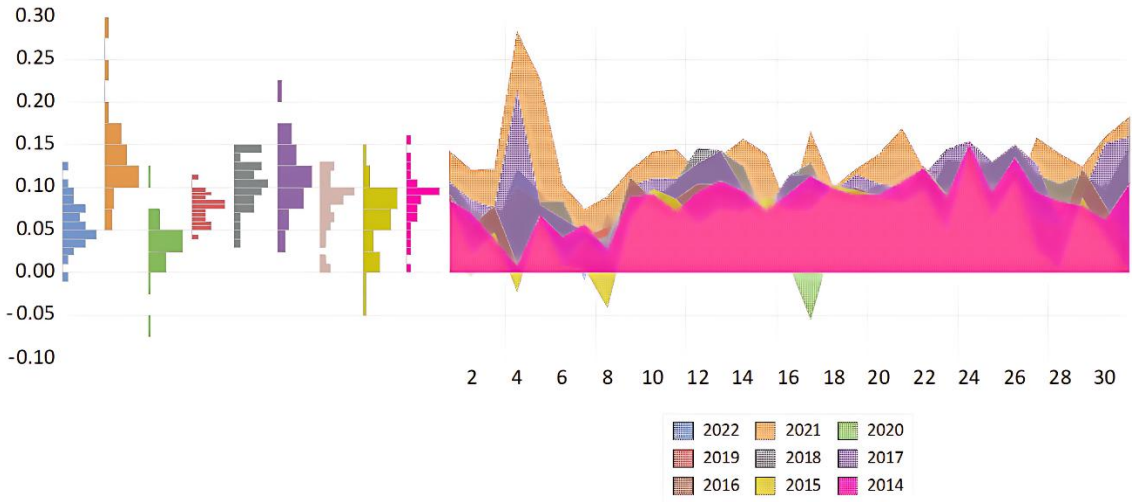

Figure 5.
Frequency distribution of EGRs for 31 PMDCGC in each year.
Sources: The original data comes from https://www.stats.gov.cn

According to Figure 5, the distribution of China's GDP growth rate showed a right skewed normal distribution from 2014 to 2020. However, the distribution of GDP growth rates in 2021 and 2022 showed a left skewed normal distribution. This just shows that although the evolution trend of the distribution of China's GDP growth rate before and after the COVID-19 epidemic is generally positive, it is an indisputable fact that China's economic development has been impacted by COVID-19, which is not less destructive, although this destructive impact cannot reverse the original trend of its economic development.

If we examine the systematic robustness of China's GDP growth rate from the perspective of coefficient of variance5, it can be seen from the following graph:

5 The formula for calculating the variance coefficient of a sample space $\{X_i\}_{i=1}^{n}$ is:$VC=\frac{S}{\bar{X}}$.

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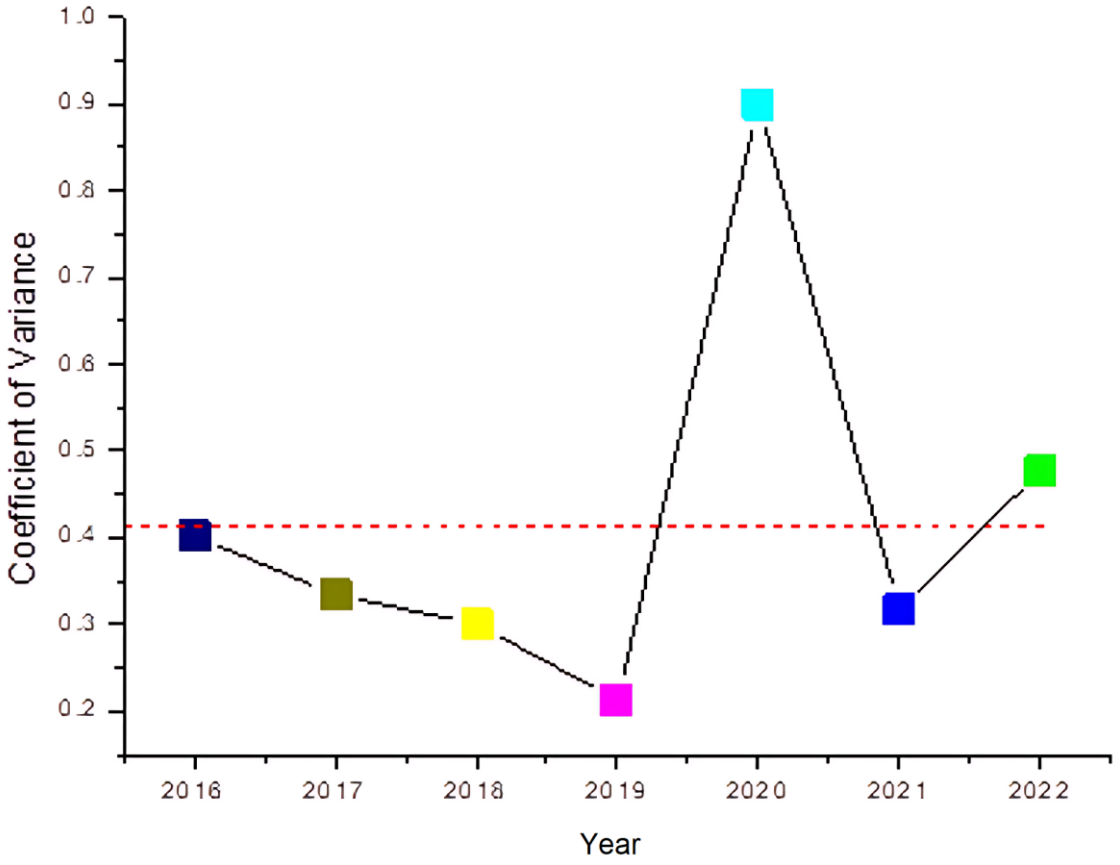

Figure 6.
Variance coefficient of GDP growth rate from 2016 to 2022.

The straight line parallel to the horizontal axis represents the average coefficient of variance of GDP growth rate in Figure 6. The coefficient of variance of GDP growth rate in 2020 is more than twice the average coefficient of variance of GDP growth rate in 7 years. However, the coefficient of variance of GDP growth rate in 2021 and 2022 regresses to a reasonable range of pre pandemic level fluctuations. This shows that the impact of the COVID-19 epidemic in 2020 on China's economic development is short-lived. In the whole economic development system, it is reasonable to regard this impact as a larger noise interference item.

Next, we will further conduct statistical tests to empirically verify how the heterogeneity of economic development is distributed between different years, that is, we will perform an H_0 hypothesis test on the expected and variance of EGRs between adjacent years. For this, we need to first calculate two statistics, namely the Z statistic and the F statistic, as shown in Table 1:

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Table 1.
Statistical Distribution of Adjacent Years from 2014 to 2022.

Year change interval	hypothesis-testing	Statistics Z	hypothesis-testing	Statistics F
2015-2014	H_0: $\mu_{2015} = \mu_{2014}$	-2.66	H_0: $\sigma_{2015} = \sigma_{2014}$	0.501
	H_1: $\mu_{2015} \neq \mu_{2014}$		H_1: $\sigma_{2015} \neq \sigma_{2014}$	
2016-2015	H_0: $\mu_{2016} = \mu_{2015}$	2.38	H_0: $\sigma_{2016} = \sigma_{2015}$	1.700
	H_1: $\mu_{2016} \neq \mu_{2015}$		H_1: $\sigma_{2016} \neq \sigma_{2015}$	
2017-2016	H_0: $\mu_{2017} = \mu_{2016}$	3.40	H_0: $\sigma_{2017} = \sigma_{2016}$	0.767
	H_1: $\mu_{2017} \neq \mu_{2016}$		H_1: $\sigma_{2017} \neq \sigma_{2016}$	
2018-2017	H_0: $\mu_{2018} = \mu_{2017}$	-0.98	H_0: $\sigma_{2018} = \sigma_{2017}$	1.453
	H_1: $\mu_{2018} \neq \mu_{2017}$		H_1: $\sigma_{2018} \neq \sigma_{2017}$	
2019-2018	H_0: $\mu_{2019} = \mu_{2018}$	-4.24	H_0: $\sigma_{2019} = \sigma_{2018}$	3.619
	H_1: $\mu_{2019} \neq \mu_{2018}$		H_1: $\sigma_{2019} \neq \sigma_{2018}$	
2020-2019	H_0: $\mu_{2020} = \mu_{2019}$	-7.27	H_0: $\sigma_{2020} = \sigma_{2019}$	0.309
	H_1: $\mu_{2020} \neq \mu_{2019}$		H_1: $\sigma_{2020} \neq \sigma_{2019}$	
2021-2020	H_0: $\mu_{2021} = \mu_{2020}$	11.08	H_0: $\sigma_{2021} = \sigma_{2020}$	0.454
	H_1: $\mu_{2021} \neq \mu_{2020}$		H_1: $\sigma_{2021} \neq \sigma_{2020}$	
2022-2021	H_0: $\mu_{2022} = \mu_{2021}$	-8.42	H_0: $\sigma_{2022} = \sigma_{2021}$	2.412
	H_1: $\mu_{2022} \neq \mu_{2021}$		H_1: $\sigma_{2022} \neq \sigma_{2021}$	

Sources: The original data comes from https://www.stats.gov.cn

According to the data in Table 1, it can be seen that there are significant differences in the economic growth levels of the 31 PMDCGC from 2014 to 2022, but there is basically no statistically significant difference in the economic development trend of these 31 PMDCGC. This shows that although the year 2020 is significantly shocked by the COVID-19 epidemic, which led to a statistically significant reduction in the economic development level in 2020, there is no significant difference between the economic development in 2020 and that in previous years. This proves that China's economic development is stable and sustainable.

From the prevention and control of COVID-19 epidemic in China, the most symbolic year is 2020. The COVID-19 epidemic has had a huge shock on the economic development in 2020, and its development level has dropped significantly. In other years, such as 2021 and 2020, and in early December 2022, with the full liberalization of the prevention and control of COVID-19 epidemic, the development of COVID-19 epidemic is completely controllable, and its shock on economic development is significantly weaker. That is why this article mainly conducts empirical research on the situation in 2020.

In fact, the data released by the National Bureau of Statistics further supports the above argument in this article.

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Table 2.
Partial data on China's socio-economic development.

Year / item	2016	2017	2018	2019	2020
GDP growth rate%	6.8	6.9	6.7	6.0	2.3
Primary industry/GDP x 100%	8.1	7.5	7.0	7.1	7.7
Secondary industry/GDP x 100%	29.6	39.9	39.7	38.6	37.8
Tertiary industry/GDP x 100%	52.4	52.7	53.3	54.3	54.5
Industrial growth rate%	5.7	6.2	6.1	6.8	2.4
Growth rate of construction industry%	7.7	3.9	4.8	5.2	3.5
Service industry growth rate%	8.1	8.3	8.0	7.2	2.1
Express delivery industry growth rate%	51.4	28.0	26.6	25.3	31.2
The growth rate of per capita disposable income of national residents,%	6.3	7.3	6.5	5.8	2.1
R&D expenditure growth rate%	10.6	12.3	11.8	12.5	10.3
Domestic tourist growth rate%	11.0	12.8	10.8	8.4	-52.1
Import/Export of Goods x 100%	75.8	81.4	85.8	83.1	79.3
Clean energy consumption/energy consumption x 100%	19.1	20.5	22.1	23.3	24.3
Growth rate of money supply%	2020				
	broad money M_2 : 10.1	narrow money M_1:8.6		Circulating currency M_0 : 9.2	

Source: National Bureau of Statistics. Statistical Bulletin on National Economic and Social Development of the People's Republic of China in 2020, February 28, 2021.

According to Table 2, China's economic development has been greatly shocked by the COVID-19 epidemic. The growth rate of China's GDP in 2020 dropped to 2.3%, compared to the GDP growth rate of 6.0% in 2019. Its growth rate has significantly shrunk, but fortunately, its growth rate has remained at a low rate of positive growth, without any negative growth. Looking at the vast majority of countries and regions in the world, China's economic development situation is still commendable compared to the basic negative growth trend in 2020. Why can China's economic development still withstand sudden century events, and what are the main reasons behind it? Perhaps there may be many perspectives on interpreting this unique phenomenon, but based on the data listed in Table 2, the following reasonable explanations can be roughly made.

Under the positive monetary policy, although the shock of the COVID-19 epidemic on the stability of money supply is huge, that is, the COVID-19 epidemic has had an shock on the monetary system, weakening the stability of the currency [49], from the overall economic pattern, it can be seen that the share of the primary, secondary and tertiary industries in the GDP of the same year is basically maintained at a relatively stable situation, especially in 2020, the share of China's three industries in the GDP of the year did not fluctuate significantly, which stabilized the overall economic situation; The growth rate of industry, construction industry, service industry, and per capita disposable income have all maintained a positive low growth trend; The growth rate of express delivery industry and R&D investment maintained a normal high growth trend, indicating that social logistics and R&D were not affected by the severe COVID-19 epidemic; Import and export have basically maintained a normal development trend; The proportion of clean energy consumption continues to increase; In 2020, the tourism industry6 will show a negative growth, that is, the growth rate is -52.1%, because all parts of the country have taken extremely strict prevention and control measures against the COVID-19 epidemic, in which the restrictions on population movement during the epidemic are routine operations, thus inhibiting a large number of cross regional flows of tourists. Based on the above measures, the ultimate result is that GDP can maintain a

[6]For China, its economic growth is a phenomenon of multiple causes and one effect, rather than just a result of some individual factors. The attribution of China's economic growth to certain single factors is clearly inconsistent with the facts. For example, using the fuzzy set qualitative analysis model to study the relationship between economic growth and tourism in China's cities, it is proposed that tourism can promote economic growth by integrating foreign capital, fixed assets investment and other resource factors [50]. The statistical data released by the National Bureau of Statistics shows that in 2020, China's tourism industry grew by -52.1%, but China's GDP had a growth rate of 2.3%.

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low-speed growth of 2.3%. This shows that the shock of the COVID-19 epidemic on China's economy in 2020 is huge, but China's economy remains stable and sustainable.

4. Methods and Data Included

4.1. Theoretical proof

Proof of Shock Theorem: Assuming that the shock capacity of X on Y is n in statistical sense, when n is large enough, such as $n \gg km$, it is said that the shock of X on Y is large-scale. Therefore, ε, the capacity is n. If ε, it's expectation is μ, the variance is σ^2, according to the central limit theorem, $\bar{\varepsilon} \sim N(\mu, \frac{\sigma^2}{n})$, where,

$$\mu = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_k \end{pmatrix}, \quad \sigma = \begin{pmatrix} {\sigma^2}_1 \\ {\sigma^2}_2 \\ \vdots \\ {\sigma^2}_k \end{pmatrix}.$$

Make transformation

$$\gamma = \frac{\bar{\varepsilon}-\mu}{\frac{\sigma}{\sqrt{n}}} = \begin{pmatrix} \frac{\overline{\varepsilon_1}-\mu_1}{\frac{\sigma_1}{\sqrt{n}}} \\ \vdots \\ \frac{\overline{\varepsilon_k}-\mu_k}{\frac{\sigma_k}{\sqrt{n}}} \end{pmatrix},$$

Then $\gamma \sim N(0,1)$. Let,

$$Y^* = \frac{\bar{Y}-\mu}{\frac{\sigma}{\sqrt{n}}} = \begin{pmatrix} \frac{\overline{y_1}-\mu_1}{\frac{\sigma_1}{\sqrt{n}}} \\ \vdots \\ \frac{\overline{y_k}-\mu_k}{\frac{\sigma_k}{\sqrt{n}}} \end{pmatrix},$$

$$\overline{f(X)}^* = \frac{\sqrt{n}}{\sigma}\overline{f(X(t))},$$

And then

$$Y^* = f^*(X(t)) + \gamma t,$$

where $\gamma \sim N(O, I)$, O is a zero matrix, and I is an identity matrix.

Therefore, according to the definition and Lemma, it is easy to infer that the shock of X on Y is effective.

Proof of Corollary 1: According to the Shock Theorem, the following Corollary 1 is obvious.

Proof of Corollary 2: According to Shock Theorem or Corollary 1, the following corollary 2 is valid.

Proof of Property 1 : According to the definition, this conclusion is obvious.

Proof of Property 2 : Following the proof method of the Shock Theorem can prove that the conclusion is valid.

Proof of Property 3: Assuming that the effective shock capacities of X_1 and X_2 on Y are n_1 and n_2, respectively, and the shock capacities of $X = aX_1 + bX_2$ on Y are taken as $n = \max\{n_1, n_2\}$. Similar to the proof of Shock Theorem, as long as attention is paid to the calculation of the expectation and variance of linear combinations, the property can be proven to be valid.

Proof of Shock Time Theirem: According to model (1), the effective shock of event matrix X on event matrix Y is closely related to the corresponding time. Assuming that T_0 and T_1 are the starting and ending times of the effective shock of event matrix X on event matrix Y, respectively, then the time T_1-T_0 is the duration of the effective shock time of event matrix X on event matrix Y. Once the duration of the shock is greater than T_1-T_0, model (1) is invalid, meaning the shock is invalid.

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Proof of Shock Marginal Attenuation Theorem: In the dynamic system $\{(X_t, Y_t)\}$ composed of event matrix X and event matrix Y, where t is the effective time. In this dynamic system, X_t is the original power source to start the dynamic system, while Y_t is the event matrix derived from X_t based on Model (1). So, under computable conditions, the dynamic chain change of the scale diffusion rate of the impact overflow can be expressed as:

$$\frac{Y_{t+1}-Y_t}{Y_t}, \frac{Y_{t+2}-Y_{t+1}}{Y_{t+1}}, \cdots, \frac{Y_{t+T}-Y_{t+T-1}}{Y_{t+T-1}},$$

where T represents the maximum length of time that the impact overflow rate is effectively extended. Due to the originality of X_t, its scale and intensity are determined, and the dynamic changes in the diffusion rate chain driven by X_t are also limited. Therefore, the dynamic time T to maintain the effectiveness of the impact is limited. In the case where positive and negative matrices can be defined and matrices can be compared in size, the effective time length T refers to the time T that satisfies the following relationship:

$$Y_{t+T+1}\text{-}Y_{t+T} \leq O,$$

where O is a zero matrix. Therefore, there are

$$\frac{Y_{t+1}-Y_t}{Y_t} \geq \cdots \geq \frac{Y_{t+T}-Y_{t+T-1}}{Y_{t+T-1}} \geq O$$

Therefore, the conclusion is valid.

4.2. Empirical Analysis on the Effectiveness of the Shock of COVID-19 Epidemic on Economic Growth

From the perspective of social normalization development, the shock of COVID-19 epidemic on social and economic development is an intermittent emergency. Under other conditions, such as the same time section in 2020, the EGR and the number of confirmed COVID-19 patients (NCCP) have the following functional relationship, that is

$$EGR = \varphi(NCCP) + \omega \qquad (6)$$

among ω Is a random perturbation term. function φ may be of various forms, including discrete or continuous function representations. Generally speaking, this function φ can be seen as a "black box" that needs to be explored, which is related to many factors that affect social and economic development, such as political wisdom, economic policies, social governance level, education level, scientific development level, and even military status. These are important factors that the construction function relies on, and there must be an inherent correlation between them. Even in a stable and sustainable socio-economic development state, the shock of sudden events such as NCCP on EGR may be significant, but it cannot be the entire element that affects EGR. There should be some unobservable related events that have sufficient shock on EGR. Therefore, these factors that are difficult to measure and have a certain shock on EGR are classified as random interference factors, which are represented by random disturbance terms.

In theory, the number of confirmed cases of COVID-19 pneumonia is a random variable. However, under the Chinese epidemic prevention and control mode[7], the fluctuation of the epidemic situation in 31 PMDCGC is within the controllable range, so the number of confirmed cases of COVID-19 pneumonia in various regions can be regarded as a relatively determined non random variable, which is consistent with the actual situation of epidemic prevention and control in China. Therefore, it is in line with scientific norms to take the number of people diagnosed with COVID-19 as an explanatory variable of economic growth in the same period.

In terms of the specific relationship between China's economic development and the COVID-19 epidemic, the function of model (6) φ is a natural logarithmic log based on natural numbers, which means there is a semi logarithmic linear relationship between EGR and NCCP based on natural numbers. Its econometric model can be set as:

[7] The Chinese model of prevention and control of COVID-19 epidemic can be summarized as the comprehensive application of these elements, that is, big data technology is used in smart phone terminals, local or remote health code tracking, normalization of all staff nucleic acid testing, optional serum screening, effective implementation of physical grading isolation, development and rapid implementation of professional vaccines, and effective treatment of traditional Chinese medicine and herbal medicine.

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$$EGR = a + b \cdot \log(NCCP) + \vartheta, \quad (7)$$

where a and b are constant coefficients, ϑ Is a random perturbation term. Now conducting regression analysis yields the following graph:

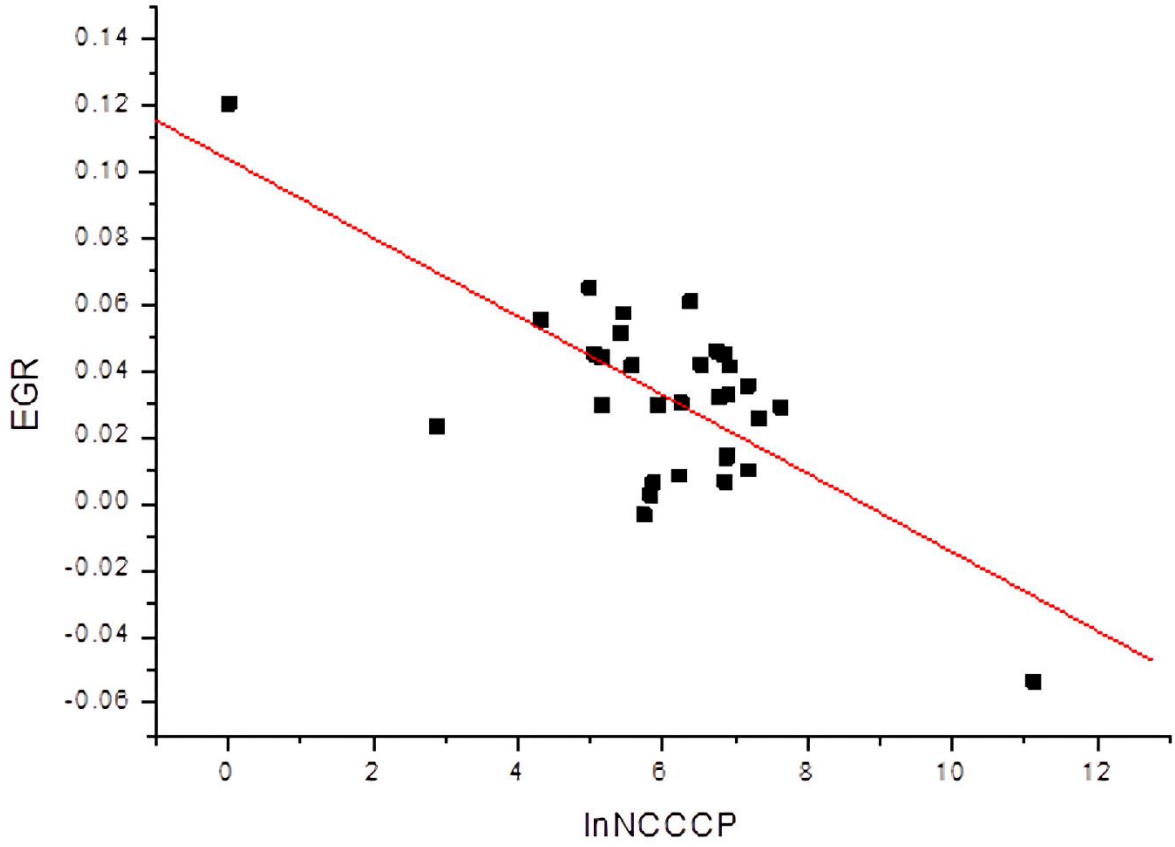

Figure 7.
Semi logarithmic linear relationship between the epidemic situation of COVID-19 and economic development.

The regression report of model (7) is as follows:

$$\widehat{EGR} = 0.104 - 0.012\log NCCP$$
$$(0.013)\ (0.002)$$
$$R^2 = 0.52 \quad SD = 0.029 \quad n = 31 \quad P < 0.001$$

The functional relationship with significant statistical significance is as follows:

$$NCCP = e^{8.77-84.6\widehat{EGR}}. \quad (8)$$

This regression function relationship (8) shows that economic development has a significant inhibitory effect on the epidemic situation of COVID-19. This statement is consistent with universal observational facts. Function (8) also indicates that if a country's economic development is relatively sluggish, its ability to respond to large-scale emergencies is extremely fragile. This illustrates an obvious truth: only when the economy develops well can any economy be able to cope with any challenges in the socio-economic system. On the other hand, when a country or region is able to demonstrate high intensity and efficiency in resisting severe challenges in the socio-economic system, it can at least indicate that the economic development foundation of the country or region is strong.

Similar to Shannon's information entropy calculation method [51], from (4), in the shock system {(EGR, NCCP)} formed by the COVID-19 epidemic in 2020 and China's economic development, the **SE** is expressed as follows:

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$\mathbf{SE}=-P(EGR,NCCP)\log_2 P(EGR,NCCP)=1.09\times10^{-6}$ (bit),
where,
$P(EGR,NCCP)=P(EGR|NCCP)\times P(NCCP)=4.469\times10^{-8}$,
$P(NCCP = t(= 1.288)) = 0.109$,
$P\big((EGR|NCCP)=t(=6.1909)\big)=4.1x.10^{-7}$.
The **SE** is almost zero, which means that although China's economic development has been shocked by the COVID-19 epidemic, its economic structure is still stable, and the resilience of economic development is still strong.

4.3. Data Description

The main sources of data are: the database of the National Bureau of Statistics of the People's Republic of China, the websites of the National Health Commission and local health commissions of the People's Republic of China, and the website of the Digital Finance Research Center of Peking University, https://data.worldbank.org/

Detailed explanation of data sources: 347 GDP data were downloaded from the National Bureau of Statistics database from 2014 to 2022, involving GDP data from 31 PMDCGC, as well as comprehensive data on the national economy; There are 93 COVID-19 epidemic data downloaded from the websites of national and local health committees, involving the first-hand data of COVID-19 epidemic monitoring data of 31 PMDCGC in 2020; Download 155 data from the Digital Finance Research Center of Peking University, involving the Digital Inclusive Finance Index of 31 PMDCGC; Download 257 valid data from the World Bank website database, covering the 2020 GDP growth rates of over 200 countries and regions.

4.4. Method Induction

To avoid redundancy, the methods involved in this article are summarized as follows:

4.4.1. Constructed A Shock Econometric Model Based on Shock Theory

This model studies the shock of sudden events on related events and has a spatiotemporal framework. Based on the characteristics of macro or micro events, the model has also made corresponding reasonable deformations to adapt to the study of shock phenomena between events in different scenarios.

4.4.2. Established Theorems Based on Statistical Shock Theory

These theorems and corollaries have broad applicability and can explain various shock cases, not limited to the case phenomena listed in this article. These theorems and corolarries reflect how the objective phenomena of shock between various events evolve, and as for the issue of right or wrong between events, the theorems or corollaries do not show corresponding value orientations or preferences, except for maintaining a standing position based on logical laws.

4.4.3. The Theoretical Basis of Empirical Econometric Models is Shock Theory

The selection of econometric models in this article only follows two principles: firstly, it does not violate the norms of shock theory; The second is to select appropriate econometric models based on the characteristics of the sample data, such as the semi logarithmic spatiotemporal econometric model and polynomial econometric model used in the article.

4.4.4. The Robustness Test of the Empirical Results Was Conducted By Selecting Diverse Means As Needed

The first method is the method of documentary evidence; The second method is statistical data validation method; The third method is analysis of variance, such as constructing F-statistics to test the annual differences in China's GDP growth rate, in order to verify its stability and sustainability; **The** fourth method is the robustness and sustainability of economic development measured by shock entropy.

5. Conclusion

The stability and sustainability of economic development have always been a hot topic of concern for countries or economies around the world. In addition to investing in the sustainability of resource

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endowments to support economic growth, perhaps more concerning is whether the original economic development path is sustainable under the impact of emergencies, which is an important indicator for measuring the robustness of economic development. The development of the Chinese economy has shown a relatively strong trend in the past few decades, and its sustainability is a focus of attention in academia and even the international community. From a macro data perspective, compared to other countries in the world, especially other economic powerful countries, the sustainability of China's economic development is highly resilient. How to measure this resilience? This article presents a new attempt, which is to use the shock entropy derived from the shock theory model constructed based on statistical significance. Through empirical means, it confirms that the sustainability of China's economic development has sufficient resilience.

Through statistical analysis, it is found that the main factors supporting the sustainability of China's economic development include the relatively perfect industrial structure layout and active monetary policy support, and the external cause is the adoption of strict epidemic prevention policies and measures for COVID-19.

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