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ВЛИЯНИЕ КРУПНЫХ ВСПЫШЕК ЭПИДЕМИЙ НА ЭКОНОМИЧЕСКОЕ РАЗВИТИЕ

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При изучении влияния эпидемии на экономику оно рассматривалось в основном как событие в целом. В существующей литературе недостаточно обозначен тот факт, что в развитии эпидемия проходит различные стадии (начало, полномасштабная вспышка, конец), а степень воздействия на экономику может существенно различаться в зависимости от стадии. Влияние эпидемии на временной ряд можно исследовать с помощью модели ARIMA – GARCH, зависящей от стадии эпидемии. В данной работе эпидемии вирусов SARS (2003), гриппа A (H1N1) (2009) и COVID-19 (2020) используются в качестве примеров при применении модели поэтапного вмешательства ARIMA – GARCH для анализа макроэкономического воздействия этих трех масштабных эпидемий. На основе полученных данных обобщается картина воздействия эпидемий на макроэкономику, чтобы обеспечить базис для принятия аргументированных решений.

Ключевые слова: макроэкономика; SARS; H1N1; COVID-19; модель ARIMA – GARCH; экономическое развитие.

THE IMPACT OF A MAJOR OUTBREAKS OF EPIDEMICS ON ECONOMIC DEVELOPMENT

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When studying the impact of an epidemic on the economy, previous studies have mainly examined the impact of the pandemic as an overall event. The fact that there are different stages in the development of an epidemic, such as the beginning, the full-blown outbreak and then the end, and that the extent of the impact on the economy can vary significantly depending on the stage of the epidemic, has been less considered in the existing literature. While analysing the impact of the epidemic on the time series, the following moments can be examined using an ARIMA – GARCH stage-specific intervention model. In this paper, we use such pandemics as SARS in 2003, Influenza A (H1N1) in 2009 and COVID-19 in 2020 as examples, and apply the ARIMA – GARCH staged intervention model to analyse the macroeconomic impact of these three sudden large-scale epidemics, and on this basis we summarise the pattern of the impact of the epidemics on the macroeconomy, so as to provide reference for the weel-informed decision-making.

Keywords: macroeconomy; SARS; H1N1; COVID-19; ARIMA – GARCH model; economic development.

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Introduction

In late 2019, the sudden outbreak of COVID-19 had a severe impact on the Chinese economy at the time. During the Chinese New Year in 2020, 78 % of food and beverage producers saw their sales revenue drop by 100 %, 80 % of wholesale and retail trade was at a standstill, while entertainment and tourism were down 85 % compared to the same period the previous year. The outbreaks of SARS, H1N1 and COVID-19 have had a negative impact on China's economic development and social stability since the beginning of the 21st century, and have challenged the Chinese government's ability to prevent and control epidemics in many areas, including production, consumption, employment and public services. The outbreak of a large-scale infectious disease usually has a serious impact on the economic development of the infected areas. In the year 2020 after the outbreak of COVID-19, China experienced a serious decline in three important areas of economic development, namely investment, consumption and exports, which coincided with the global economic downturn and the weakness of the global economy and the complex multilateral environment of the international market. These factors have put China's foreign trade exports in a critical situation. Therefore, an in-depth analysis and study of the impact of the epidemic on the economy and the characteristics of these adverse effects at different stages of the epidemic will help countries to optimise the coordination between epidemic prevention and control policies and economic development, so as to ensure that economic development can be carried out in a healthy and sustainable manner in line with the needs of epidemic prevention and control.

Literature review

Since the onset of COVID-19, many international scholars have expressed many views on its impact on the economy. Recent evidence suggests that sudden pandemic outbreak have a negative impact on the economy. Liu Weidong reports that pandemic has had a huge impact on people's health and daily lives, economic growth and employment, and national and international governance [1]. Commenting on international trade, Yu Ziqing and C. G. Gospodarik argue that, in the case of China, the epidemic has had a negative impact on international trade [2]. As V. Nitsch notes that the impact of the COVID-19 pandemic on international trade varies along several dimensions, including the type of product, the size of firm and over time [3]. Other researchers, however, who have looked at opportunities under pandemic found that the digital economy can be an effective driver of economic recovery [4]. This article selects three pandemics to more fully analyse their impact on national economies, both in terms of supply and demand.

Definition of the concept of sudden pandemic outbreak

An epidemic outbreak is not only a threat to public health but also an impediment to economic development, and is often understood as a one-off widespread outbreak of an epidemic that persists over time and space and has a tendency to spread and expand the number of people infected. Three typical large-scale outbreaks are used in this thesis, namely SARS, H1N1 and COVID-19. The first type of cases was the SARS outbreak in Guangdong province, China, in 2003, which spread to 26 provinces, cities and autonomous regions of China in the months following the outbreak, causing a huge impact on China's tourism and transportation industries and placing a heavy burden on the Chinese healthcare system at the time. The second type of case was a major epidemic outbreak in the United States in 2009 caused by the H1N1 virus, which affected 214 countries and territories worldwide. By December of that year 123 000 people worldwide had been diagnosed with the H1N1. The third type of cases is the first case of COVID-19 infection detected in December 2019 in Wuhan, China, where the outbreak spread rapidly and developed into a nationwide epidemic within a month. The total number of confirmed cases in 31 provinces and regions of China by the end of 2021 was 102 300. All three cases of epidemic outbreaks meet the definition of a sudden mass outbreak. Therefore, from these three examples of sudden epidemics, the author has observed the impact of the various stages of sudden epidemics on various aspects of the economy.

Empirical analysis of the impact of sudden large-scale epidemics on China's macroeconomy

Research methodology. The idea of an ARIMA model is to input the residuals of the variable under study into the model on a time series basis. The idea of this traditional method of time series analysis is to insert the residuals of the variables under study into the model on a smoothed series basis in order to improve the accuracy of the model analysis and forecasting. However, in real life, especially in the economic field, some economic behaviours are often affected by major or unexpected external events, such as sudden wars, sudden epidemics, political events or major policy actions. We refer to such special events as «interventions», and when «interventions» are included as intervening variables in an ARIMA model, the model is referred to as an ARIMA intervention model, which can be better adapted to the actual situation. Xu Xiumei and Wu Lihui introduced crisis events such as SARS and the financial crisis as dummy variables in the ARIMA model to quantitatively analyse the impact of different crisis events on tourism [5; 6]. Wang Shuping used an ARIMA – GARCH model in his study of the impact of war stages on oil price volatility [7]. The authors argue that war is an external shock and that it is appropriate to use dummy variables to represent the different phases of war, and that GARCH models can also be introduced when there is heteroskedasticity in the model errors. Similarly, in [8] ARIMA – GARCH stage intervention model is used to investigate the impact of the oil workers' strike phase on oil prices. Based on the above research considerations on the impact of unexpected events on economic variables, this paper takes the SARS epidemic, Influenza A (H1N1) and the COVID-19 as examples and constructs an ARIMA – GARCH staged intervention model based on the characteristics of the epidemics. Assuming that an unexpected large-scale epidemic is characterised by the occurrence of some major events divided into n phases, the dummy variable i_t is introduced to represent the n time point of the i phase of the epidemic, which is defined as follows:

$$w_{it} = \begin{cases} 1 \text{ if moment } t \text{ is within phase } i,\ i = 1, \ldots, n, \\ 0 \text{ if others.} \end{cases}$$

Then the basic ARIMA phased intervention model is:

$$y_t = c + \sum_{i=1}^{n} \alpha_i w_{it} + \sum_{i=1}^{p} \varphi_i y_{t-i} + \varepsilon_t - \sum_{i=1}^{q} \phi_i \varepsilon_{t-i},\ t = 1, \ldots, T, \tag{1}$$

where y_t is the time series or difference series of an economic indicator (if there is seasonality in an economic series, then y_t is the seasonally adjusted time series or difference series); c is a constant term; p, q are the lagged order; T is the total number of periods examined; α_i, φ_i, ϕ_i are the coefficients of the stage variable w_{it}, the economic indicator lag variable y_{t-i}, and error lagged variables ε_{t-i}. The effect of the epidemic on the economic indicators in model (1) is $\sum_{i=1}^{n} \alpha_i \left(1 - \sum_{i=1}^{p} \varphi_i\right)^{-1}$. In general, the stage variables w_{it} has a lagged effect on y_t, then the basic model can be modified as:

$$y_t = c + \sum_{i=1}^{n} \sum_{j=0}^{m_i} \alpha_{ij} w_{i(t-j)} + \sum_{i=1}^{p} \varphi_i y_{t-i} + \varepsilon_t - \sum_{i=1}^{q} \phi_i \varepsilon_{t-i},\ t = 1, \ldots, T, \tag{2}$$

where m_i is the lag order of the i stage of the epidemic. The long-run effect of the epidemic affecting economic indicators in model (2) is $\sum_{i=1}^{n} \sum_{j=0}^{m_i} \alpha_{ij} \left(1 - \sum_{i=1}^{p} \varphi_i\right)^{-1}$. If there is heteroskedasticity in the errors of the model before and after the epidemic, the basic model is modified to an ARIMA – GARCH phased intervention model:

$$\begin{cases} y_t = c + \sum_{i=1}^{n} \sum_{j=0}^{m_i} \alpha_{ij} w_{i(t-j)} + \sum_{i=1}^{p} \varphi_i y_{t-i} + \varepsilon_t,\ \varepsilon_t = v_t - \sum_{i=1}^{q} \phi_i \varepsilon_{t-i}, \\ v_t = \sqrt{h_t} e_t,\ h_t = w + \sum_{i=1}^{k} \beta_i v_{t-i^2} + \sum_{j=1}^{l} \gamma_j h_{t-j},\ e_t \sim IN(0.1). \end{cases} \tag{3}$$

The long-term effects of the epidemic affecting economic indicators in model (3) are the same as in model (2). When analysing the impact of the stages of the epidemic on y_t, only the different stage of the epidemic are considered without other factors, on the basis of excluding seasonal factors, calendar effects and satisfying data availability and authenticity.

When conducting the empirical analysis, the ARIMA model requires the time series of the dependent variable to be stationary, therefore, the time series y_t is firstly tested for stationarity in the selection of the dependent variable, and if it is not stationary then it is differenced until it is stationary, and if there is significant seasonality in the data, it is seasonally adjusted before the stationarity test. Afterwards, referring to Wu Zhenxin and Zhou Minglei [7], Granger causality tests were conducted on y_t or Δy_t overall and at stage to check whether the epidemic affects y_t or Δy_t and based on test the model dependent variable is selected based on the results: if the epidemic affects Δy_t then Δy_t is selected as the dependent variable, if Δy_t is not affected but can affect y_t then y_t is selected as the dependent variable, and if neither is affected then indicates that no modelling information exists and no intervention model is created at this point. For model selection, in order to build a suitable model, model (1) was used for initial analysis and model (2) or (3) was selected based on the goodness of fit test, t-value test, error series correlation test and heteroskedasticity test, while the lag order of the variables was determined based on the t-value magnitude and AIC criterion. Finally, the extent to which the epidemic affects the macroeconomy in general and in phase is analysed basing on the test results and the model results.

Indicator and event selection

In terms of the selection of events, three typical epidemics, SARS (2003), H1N1 (2009) and COVID-19 (2020), were selected based on the definitions in previous content to verify the applicability of the model and the overall impact of the epidemics on selected macroeconomic indicators. Finally, the analysis of the model leads to current situation of the impact of epidemic on the macroeconomic development of China. To facilitate the observation of the impact of the epidemic on macroeconomic indicators, the periods in which the epidemic occurred were placed in the middle of the time series as far as possible, while ensuring the accuracy and precision of the data.

The process of empirical analysis

Macroeconomic impact of the SARS epidemic. *Analysis of the impact of the SARS epidemic on industrial value added.* The outbreak of SARS in 2003, as a sudden large-scale epidemic, has had a more or less significant impact on the macroeconomic level in China. The SARS epidemic went through three main phases of development from discovery to mitigation, namely the beginning phase, the outbreak phase and the end of the epidemic. The first confirmed case appeared in Guangdong province on 5 December 2002, and by the end of March a total of 1190 confirmed cases had been reported in the mainland of China, of which 1153, or 97 %, were in Guangdong. From April to May 2003, the SARS epidemic began to spread to most other provinces, with the number of sick. In June, the SARS epidemic entered a period of remission, with a gradual decline in cases, during which a series of policies were introduced to gradually lift the quarantine and the epidemic was basically over by July.

Based on the above analysis, the following three-stage variables are defined:

$$w_{1t} = \begin{cases} 1 \text{ if } 05.12.2002 \le t \le 31.03.2003, \\ 0 \text{ if others,} \end{cases}$$

$$w_{2t} = \begin{cases} 1 \text{ if } 01.04.2003 \le t \le 31.05.2003, \\ 0 \text{ if others,} \end{cases}$$

$$w_{3t} = \begin{cases} 1 \text{ if } 01.06.2003 \le t \le 31.07.2003, \\ 0 \text{ if others.} \end{cases}$$

Combining the three stage variables into one overall variable:

$$w_{t} = \begin{cases} 1 \text{ if } 05.12.2002 \le t \le 31.07.2003, \\ 0 \text{ if others.} \end{cases}$$

The phasing of the other two outbreaks can be done similarly. For the analysis of the impact of SARS on industrial value added, monthly data were used as daily values were difficult to obtain, and the period examined was from 1 January 2001 to 31 December 2005, with 60 months of observations, with the SARS epidemic in the middle to facilitate observation of its impact on the indicators. As there is significant seasonality in the original series, the series is first seasonally adjusted to remove seasonal factors and calendar effects, and the seasonally adjusted industrial value added is represented by y_t, as shown in fig. 1 that is developed on the basis of data of National Bureau of Statistics of China[1].

After seasonal adjustment, by observing the trend of the data, it was found that there was no obvious exponential trend and not much fluctuation, so no logarithm treatment was done for y_t. After that, a smoothness test was performed on y_t. The ADF unit root test indicated that the industrial value added series y_t was not smooth while the first order difference Δy_t was smooth. After that, Granger causality tests were conducted on Δy_t and the SARS epidemic at both the overall and stage levels. The test results showed that the SARS epidemic was not the Granger cause of Δy_t at both the overall and stage levels, which said that the SARS epidemic could not significantly affect the speed and magnitude of the change in industrial value added. When Δy_t is not affected,

[1]Industrial value added [Electronic resource]. URL: https://wenku.baidu.com/view/b8918c3187c24028915fc325.html?_wkts_=1677857094993&bdQuery=2002年一月工业增加值 (date of access: 07.12.2022) (in Chin.).

and then whether the SARS epidemic affects y_t at the overall and stage levels, the test results show that the SARS epidemic is also not a Granger cause of y_t indicating that SARS cannot significantly affect the level of industrial value added. When neither Δy_t nor y_t was affected, no modelling information existed at this point and no intervention model was required. The results of the tests are shown in table 1.

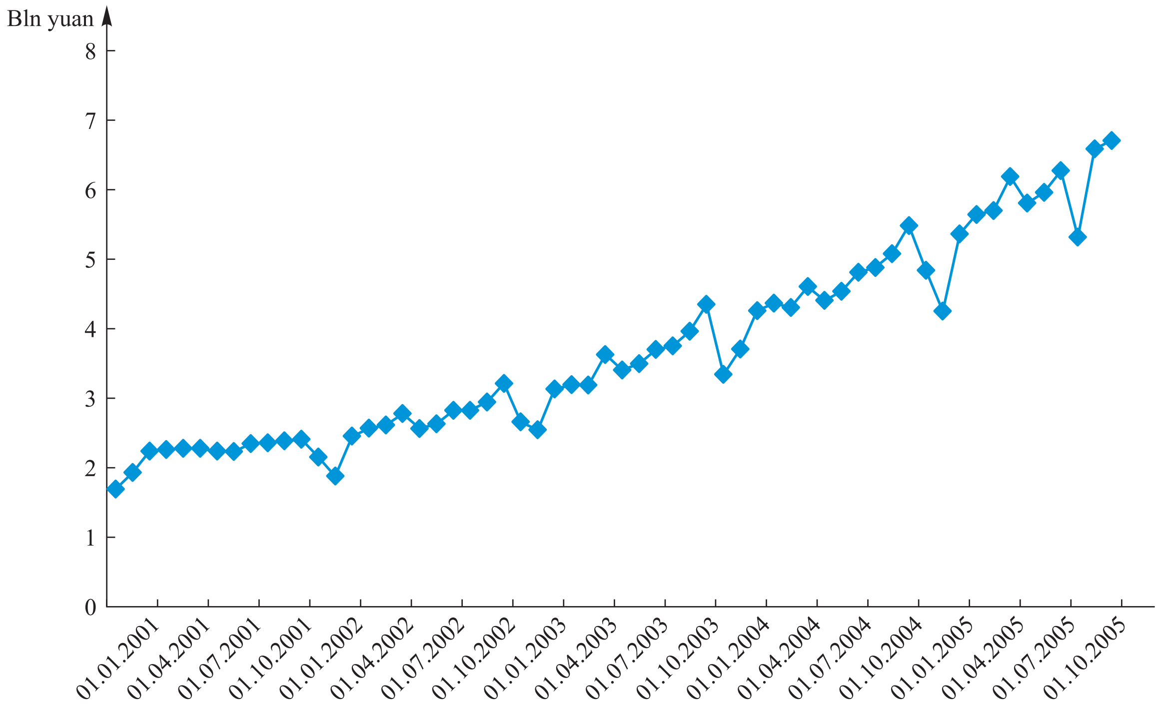

Fig. 1. Industrial value added 2001–2005

Table 1

SARS epidemic stages and tests

Indicator	Time period of the visit	Overall inspection	Staging	Phase test
Industrial value added	2001–2005	Not significant	05.12.2002–31.03.2003	Not significant
			01.04.2003–31.05.2003	Not significant
			01.06.2003–31.07.2003	Not significant

N o t e. The significance level of the test is 0.05.

As can be seen from the test results, SARS, as an external factor, did not interfere with the changes in industrial value added, the supply side of China's macroeconomy was largely unaffected by the SARS epidemic in terms of both absolute and relative data values, which is more in line with reality. As can also be seen in fig. 1, there was no significant decline or abnormal fluctuations in industrial value added during the SARS period.

Analysis of the impact of the SARS epidemic on total retail sales of consumer goods. On the macroeconomic side, total retail social goods are selected to represent the demand side of the macroeconomy, and the period under examination is not change. The variation is observed for a total of 60 months, and as there is significant seasonality in the original series, the series is first seasonally adjusted and the seasonally adjusted total social retail sales goods are represented by y_t, as shown in fig. 2 that is developed on the basis of data of National Bureau of Statistics of China[2].

The results of the ADF test indicated that total social retail goods y_t was not smooth, while the first-order difference Δy_t was smooth. Granger causality tests were conducted on Δy_t and SARS, both overall and at stage, and the results are shown in table 2.

[2]Social retail merchandise [Electronic resource]. URL: https://data.stats.gov.cn/easyquery.htm?cn=A01&zb=A0701&sj=200112 (date of access: 07.12.2022).

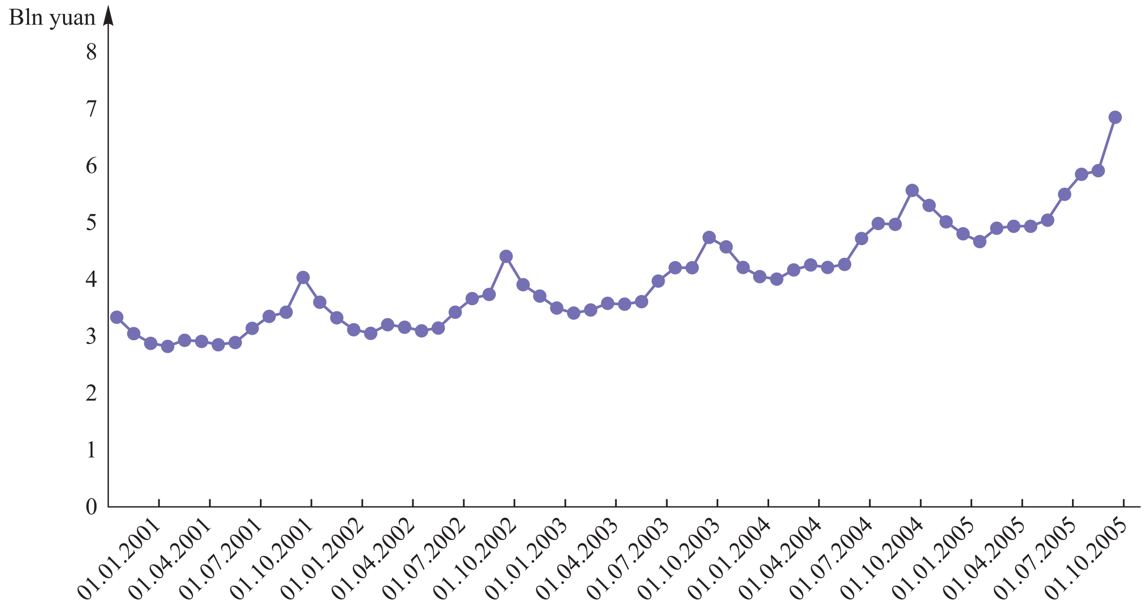

Fig. 2. Total social retail merchandise 2001–2005

Table 2

SARS epidemic stage classification and tests

Indicator	Time period of the visit	Overall inspection	Staging	Phase test
Total retail sales of social consumer goods	2001–2005	Significant	05.12.2002–31.03.2003	Significant
			01.04.2003–31.05.2003	Not significant
			01.06.2003–31.07.2003	Not significant

Note. The significance level of the test is 0.1.

Considering the SARS epidemic as a whole, it has a lagged effect on the change in total retail sales of consumer goods. This table indicating that the SARS epidemic had a negative impact on the change in macro demand at the beginning of the period. The SARS epidemic only had a short-lived negative impact on economic demand at the beginning of the period. At the same time, during the SARS period our economy was in the process of a rapid upward cycle and the damage caused to our economy was lower than the effect of the release of economic growth potential, and because of this, the impact of the latter two phases of the SARS epidemic (the outbreak phase and the recession phase) was not significant, as confirmed by the results of the Granger casuality test. Therefore, when analysing the impact of the epidemic on the economy, it is important to look not only at the impact of the epidemic as a whole, but also from the perspective of the phases of impact. Furthermore, by comparing the impact of SARS on industrial value added and total retail sales of consumer goods, it can be seen that the impact of SARS on the macro economy is more at the demand level rather than the supply level.

Macroeconomic impact of Influenza A (H1N1). *Analysis of the impact of Influenza A (H1N1) on industrial value added.* Influenza A (H1N1) was the first to break out in Mexico, and in May of the same year, the first imported confirmed cases emerged in China's Sichuan province, after which confirmed cases continued to increase. On 18 September 2009 the WHO director general said that Influenza A (H1N1) was spreading rapidly around the world, and with the onset of winter in the northern hemisphere, the second wave of transmission had begun. By the end of December 2009, 123 000 cases of the new H1N1 were confirmed in mainland China. Early 2010, Influenza A entered a period of decline, and by the end of March 2010, more than 127 000 confirmed cases had been reported in 31 provinces across the country. Although the end of the Influenza A (H1N1) pandemic was only declared by the WHO on 10 August 2010, its impact has been inconsequential since April 2009. Based on the previous analysis, defining the three-stage variable, namely

$$w_{1t} = \begin{cases} 1 \text{ if } 11.05.2009 \le t \le 17.09.2009, \\ 0 \text{ if others,} \end{cases}$$

$$w_{2t} = \begin{cases} 1 \text{ if } 18.09.2009 \le t \le 03.12.2009, \\ 0 \text{ if others,} \end{cases}$$

$$w_{3t} = \begin{cases} 1 \text{ if } 01.01.2009 \le t \le 31.03.2010, \\ 0 \text{ if others.} \end{cases}$$

Three stage variables are combined into one overall variable:

$$w_t = \begin{cases} 1 \text{ if } 25.04.2009 \le t \le 31.03.2010, \\ 0 \text{ if others.} \end{cases}$$

Industrial value added was chosen to represent the supply side of the macroeconomy and the period examined was from 1 January 2007 to 31 December 2011, a total of 60 months of observations, with influenza located in the middle to facilitate observation of its impact on the indicator. The series was first seasonally adjusted and the seasonally adjusted industrial value added is shown in fig. 3 that is developed on the basis of data of National Bureau of Statistics of China[3].

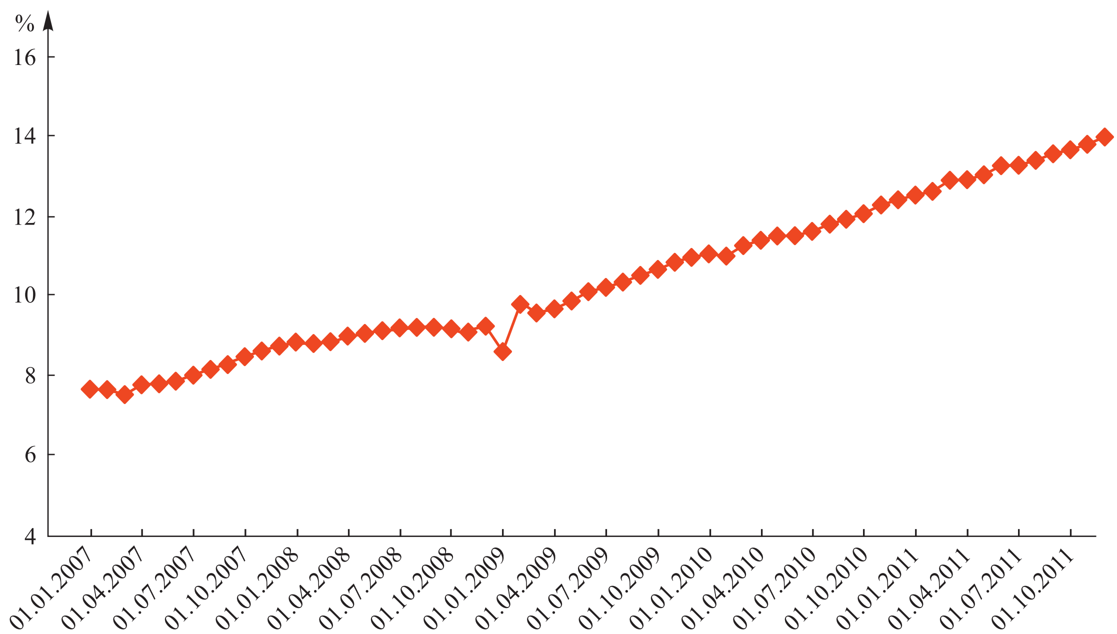

Fig. 3. Industrial value added 2007–2011

After seasonal adjustment, by observing the trend of the data, it was found that the linear trend was obvious and less volatile, so no logarithmic treatment was done for y_t and the other indicators were done similarly. The ADF test results indicated that the seasonally adjusted series of industrial value added y_t was not smooth while Δy_t was smooth. Subsequently, Granger causality tests on Δy_t and Influenza A (H1N1) at both the overall and stage levels found that Influenza A was not the Granger cause of Δy_t. Looking again at whether influenza affects y_t overall and at stage, the test results indicate that influenza is also not a Granger cause of y_t. Neither Δy_t nor y_t was affected, indicating that influenza could not significantly affect the level, speed and magnitude of industrial value added, and therefore no modelling information was present and no intervention model was required. The results of the tests are shown in table 3.

Table 3

Influenza A (H1N1) stage classification and tests

Indicator	Time period of the visit	Overall inspection	Staging	Phase test
Industrial value added	2007–2011	Not significant	11.05.2009–17.09.2009	Not significant
			18.09.2009–31.12.2009	Not significant
			01.01.2010–31.03.2010	Not significant

Note. The significance level of the test is 0.05.

[3]Industrial valued added [Electronic resource]. URL: http://www.stats.gov.cn/search/s?qt=工业增加值 (date of access: 07.12.2022) (in Chin.).

The results here are similar to those of the SARS epidemic, Influenza A (H1N1) did not interfere with industrial value added and its changes, the supply side of our macroeconomy was not affected by the flu. This conclusion can also be verified by the trend of the indicators in fig. 3, where industrial value added has not shown unusual fluctuations since the onset of the flu in May 2009.

Analysis of the impact of Influenza A (H1N1) on total social retail sales of goods. Total social retail merchandise was chosen to represent the demand side of the macroeconomy, with the period of investigation unchanged and the flu located in the middle to facilitate observation of its impact on the indicator. The series was seasonally adjusted to remove seasonal factors and calendar effects, and the seasonally adjusted total social retail merchandise is shown in fig. 4 that is developed on the basis of data of National Bureau of Statistics of China[4].

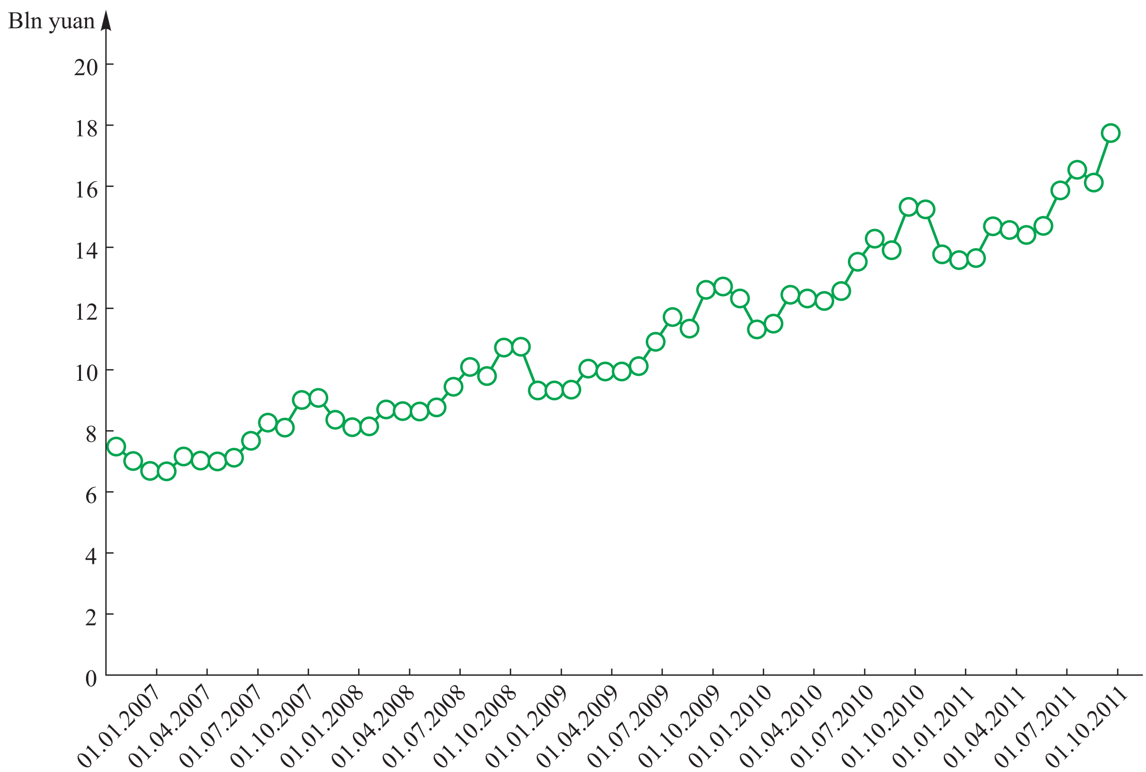

Fig. 4. Total social retail merchandise 2007–2011

The results of the ADF test indicated that the first-order difference Δy_t of total social retail goods was smooth, and Granger causality tests were conducted on Δy_t and Influenza A (H1N1), both overall and at stage, and the results are shown in table 4.

Table 4

Influenza A (H1N1) stage classification and tests

Indicator	Time period of the visit	Overall inspection	Staging	Phase test
Total retail sales of social consumer goods	2007–2011	Not significant	11.05.2009–17.09.2009	Not significant
			18.09.2009–31.12.2009	Not significant
			01.01.2010–31.03.2010	Not significant

Note. The significance level of the test is 0.05.

The model was built based on the test results and the estimation results are shown in table 5.

[4]Social retail merchandise [Electronic resource]. URL: https://data.stats.gov.cn/easyquery.htm?cn=A01&zb=A0701&sj=200701 (date of access: 08.12.2022).

Table 5

Model estimation results

Explanatory variables	c	w_1	$w_{2(t-1)}$	$w_{3(t-5)}$	y_{t-1}	ε_{t-1}
Coefficient	0.1450***	0.4326***	–0.3653**	0.0829	0.4169**	–0.1894
Testing	R^2 = 0.35, DW = 2.02, F = 5.26 (0.000)					

N o t e. Signs *, **, *** indicate significant at the 10, 5, 1 % levels respectively.

The specific model is shown in equation

$$Ay_t = 0.1450 + 0.4169y_{t-1} + 0.4326w_1 - 0.3653w_{2(t-1)} + 0.0829w_{3(t-5)} + \varepsilon_t - 0.1894\varepsilon_{t-1}. \quad (4)$$

Taking Influenza A (H1N1) as a whole, it has a lagged effect on changes in macro demand. The three phases of influenza have a significant impact, and in terms of the impact effect, the beginning phase of influenza did not have a negative impact on macro demand as it was not very harmful. After the full outbreak of influenza in September, the phase variable w_2 had a lagged negative impact on macro demand, causing the change in total social retail goods to fall by 0.3653. At the same time, the phase variable w_3 has a lagged positive effect, suggesting that as influenza moves into recession, the negative impact of the epidemic diminishes under the influence of preventive and control measures and proactive policies. Furthermore, by comparing the results of the macroeconomic impact of the two influenza outbreaks, it can be seen that, similar to the SARS epidemic, the macroeconomic impact of Influenza A (H1N1) was more at the demand level than the supply level.

Macroeconomic impact of COVID-19. *Analysis of the impact of the COVID-19 on industrial value added.* The sudden outbreak of COVID-19 in early 2020 posed a certain threat to national health while also having a negative impact on the macro economy. The epidemic lasted for a long time and the epidemic phases were more obvious. With reference to scholars such as the white paper «China's action against COVID-19», this paper roughly divides the development of COVID-19 into three phases, namely the beginning phase, the outbreak phase and the decline phase. Here, on the basis of grasping the characteristics of the epidemic, only the epidemic is divided into three phases, which on the one hand on 8 December 2019, the Wuhan Health Commission announced the first case of COVID-19, and on 30 January 2020, the WHO classified the pandemic outbreak as an international public health emergency, marking the beginning of the outbreak phase, during which China closed the country. The third phase of the outbreak was from April 2020 to December 2021, when Wuhan was unsealed in April 2020 and a series of policies were introduced in various regions, during which the epidemic was generally sporadic, although there were localised cases of epidemic caused by aggregation, but the epidemic was always under normal prevention and control, and the epidemic was basically under control in the country. The epidemic was basically under control, so basically the third phase of the epidemic can be regarded as the decline phase.

Next, the impact of the phase of COVID-19 on industrial value added and total social retail goods is examined separately. Based on the previous analysis, a three-stage variable is defined:

$$w_{1t} = \begin{cases} 1 \text{ if } 08.12.2019 \leq t \leq 29.01.2020, \\ 0 \text{ if others}, \end{cases}$$

$$w_{2t} = \begin{cases} 1 \text{ if } 30.01.2020 \leq t \leq 31.03.2020, \\ 0 \text{ if others}, \end{cases}$$

$$w_{3t} = \begin{cases} 1 \text{ if } 01.04.2020 \leq t \leq 31.12.2021, \\ 0 \text{ if others}. \end{cases}$$

Combining the three stage variables into one variable, i. e.

$$w_t = \begin{cases} 1 \text{ if } 08.12.2019 \leq t \leq 31.12.2021, \\ 0 \text{ if others}. \end{cases}$$

Industrial value added was selected to represent the supply side of the macro economy, and the period examined was from 1 January 2017 to 31 December 2021, a total of 60 months of observations. The series was seasonally adjusted to remove seasonal factors and calendar effects, and the seasonally adjusted industrial value added is shown in fig. 5 that is developed on the basis of data of National Bureau of Statistics of China[5].

[5]Industrial value added [Electronic resource]. URL: http://www.stats.gov.cn/search/s?qt=工业增加值 (date of access: 08.12.2022) (in Chin.).

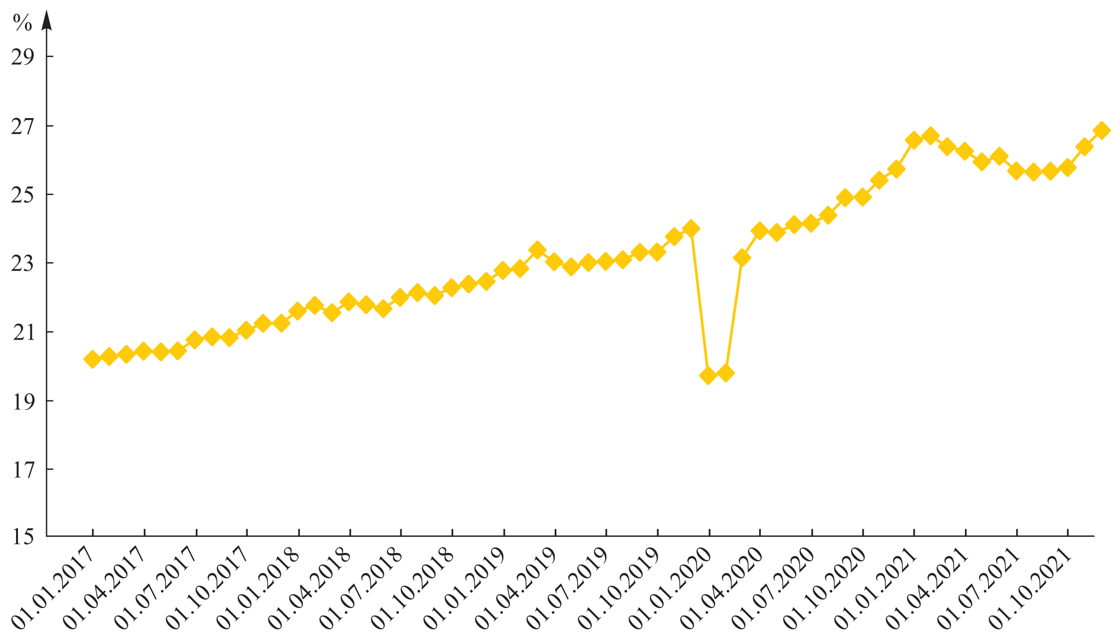

Fig. 5. Industrial value added 2017–2021

The ADF test results indicated that the industrial value added series was not smooth while the first-order difference series was smooth, and Granger causality tests were performed on Δ, both overall and at stage, and the results are shown in table 6.

Table 6

COVID-19 outbreak stage classification and testing

Indicator	Time period of the visit	Overall inspection	Staging	Phase test
Industrial value added	2017–2021	Significant	08.12.2019–29.01.2020	Significant
			30.01.2020–31.03.2020	Significant
			01.04.2020–31.12.2021	Significant

Note. The significance level of the test is 0.05.

The model was built based on the test results and the estimation results are shown in table 7.

Table 7

Model estimation results

Explanatory variables	c	$w_{1(t-1)}$	$w_{2(t-1)}$	$w_{2(t-2)}$	w_{3t}	Δy_{t-3}	$\varepsilon_{(t-1)}$	$\varepsilon_{(t-2)}$
Coefficient	0.0943***	–2.1806***	2.9732***	–0.7639*	0.0451	0.3662**	–0.6256***	0.3490**
Testing	R^2 = 0.73, DW = 1.96, F = 17.96 (0.000)							

Note. Signs *, **, *** indicate significant at the 10, 5, 1 % levels respectively.

The specific model is shown in equation

$$\Delta y_t = 0.0943 + 0.3662\Delta y_{t-3} - 2.1806w_{1(t-1)} + 2.9732w_{2(t-1)} - \\ - 0.7639w_{2(t-2)} + 0.0451w_3 + (-0.6256)\varepsilon_{(t-1)} - 0.3490\varepsilon_{(t-2)}. \quad (5)$$

The results of the model show that all three periods of COVID-19 had a significant impact on the change in industrial value. Among these factors, the phase variable $w_{1(t-1)}$ had a significant negative effect on industrial value added, with 2.1806 falling sharply from January 2020 onwards, from the beginning of the new COVID-19 outbreak to the end of February. Thus, between February and March 2020, the change in industrial value added did not decrease further despite the outbreak of the new virus, and the effect of the phase variable $w_{2(t-1)}$ was positive despite a series of policy stimuli, while the change in industrial value added was 2.973 2. Following the outbreak of COVID-19, the growth rate of change in China's industrial value added has slowed and the pressure of economic decline has increased. It is therefore important to analyse the impact of the epidemic as a whole, as well as the impact generated by the economy in each period. Depending on the length of the pandemic outbreak, unlike the SARS and H1N1 viruses, COVID-19 had a negative impact on macro supply at the beginning of the outbreak, whereas the other two outbreaks did not «affect» macro supply, suggesting that the impact of the epidemic was more severe.

Analysis of the impact of COVID-19 on total retail social goods. Total social retail merchandise was selected to represent the demand side of the macroeconomy, with a total of 60 months of observations for a constant period of examination. The series is seasonally adjusted and the seasonally adjusted total retail social goods are shown in fig. 6 that is developed on the basis of data of National Bureau of Statistics of China[6].

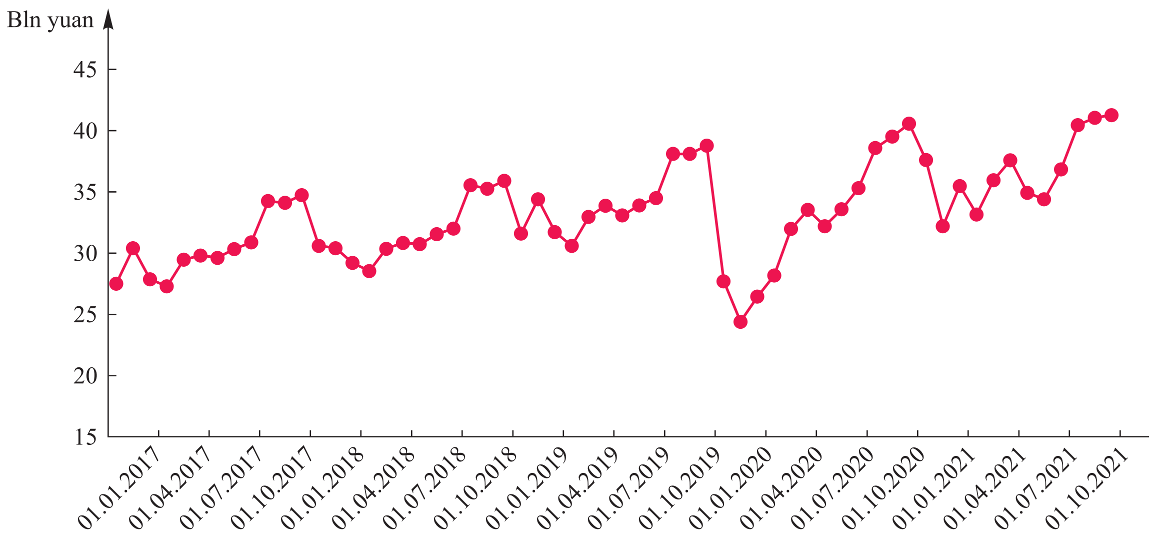

Fig. 6. Total social retail merchandise 2017–2021

The results of the ADF test indicated that the first-order difference series of total social retail goods Δy_t was smooth, followed by Granger causality tests on the overall and stage of the new crown epidemic and Δy_t the results of which are shown in table 8.

Table 8

COVID-19 outbreak stage classification and tests

Indicator	Time period of the visit	Overall inspection	Staging	Phase test
Total retail sales of social consumer goods	2017–2021	Significant	08.12.2019–29.01.2020	Significant
			30.01.2020–31.03.2020	Significant
			01.04.2020–31.12.2021	Not significant

Note. The significance level of the test is 0.05.

The model was built based on the test results and the estimation results which are shown in table 9.

Table 9

Model estimation results

Explanatory variables	c	$w_{1(t-1)}$	$w_{2(t-1)}$	w_{3t}	Δy_{t-3}	$\varepsilon_{(t-1)}$	$\varepsilon_{(t-2)}$	$\varepsilon_{(t-3)}$
Coefficient	0.163 7**	–2.749 2***	–3.467 7***	0.526 1	–0.713 7***	–0.924 5***	0.641 9***	–0.540 5***
Testing	$R^2 = 0.60$, DW = 2.07, F = 8.19							

Note. Signs *, **, *** indicate significant at the 10, 5, 1 % levels respectively.

[6]Social retail merchandise [Electronic resource]. URL: https://data.stats.gov.cn/search.htm?s=社会零售总额 (date of access: 08.12.2022) (in Chin.).

The model results show that the phase variables w_1 and w_2 have a direct negative impact on the change in total retail sales of consumer goods. This suggests that macro demand was more negatively affected at the beginning and shortly after the outbreak of the new epidemic, resulting in a decline in the change in total retail sales of consumer goods by 2.7492 and 3.4677 respectively. However, the recovery is a process and macroeconomic indicators are not responding fast enough. It is important to note that the test results show that the impact of the phase variable w_3 is insignificant and therefore does not enter the model, as economic demand is more affected during the initial and outbreak phases of the epidemic and the recovery in demand is more due to the economy's own long-term trends. In terms of impact, the impact of COVID-19 epidemic is greater than that of the SARS epidemic phase, which is also related to the structural changes in the Chinese economy, where consumption has become the main driver of growth compared to the SARS phase, and consumer demand, as an important component of macro demand, is more affected by COVID-19 in the consumption sector the impact of the epidemic was greater, so the epidemic had a negative impact on the development of macro demand, both overall and in individual phases.

Analysis of the macroeconomic characteristics of the impact of sudden large-scale outbreaks. The main features of the impact of the three sudden large-scale outbreaks on macroeconomic indicators analysed earlier are summarised below in table 10.

Table 10

Summary of the macroeconomic characteristics of the impact of sudden large-scale outbreaks

Impact industries and indicators	Outbreaks affecting indicators	Overall impact	Stages of significant impact
Industrial value added	SARS	Not significant	–
	Influenza A (HlNl)	Not significant	–
	COVID-19	Significant	The beginning, explosion, decline phase
Total retail sales of social consumer goods	SARS	Significant	The beginning phase
	Influenza A (HlNl)	Not significant	
	COVID-19	Significant	The beginning, explosion phase

The following points can be drawn from table 10.

In terms of the impact of the epidemic, the similarity between the three outbreaks of large-scale epidemics is that the occurrence of the epidemic mostly had a certain impact on the demand side of the macroeconomy, while it had less impact on the supply side of the macroeconomy, with all three epidemics causing a certain impact on the macro demand side, and only the COVID-19 had a certain impact on the macrosupply side. The difference is that the three epidemics had different degrees of impact on the demand side of the economy, and from the overall impact, COVID-19 had the greatest impact, the SARS epidemic the second and Influenza A (H1N1) the least.

The impact of the phase of a sudden large-scale epidemic on the economy mostly has a lag, for example, from the start of the epidemic to the full outbreak, and then to the release of quarantine and the resumption of work and production, a process is required, and macroeconomic indicators do not respond quickly enough as a result. Comparing the three epidemics together, in general, the epidemic had a lagged negative impact on macro demand at the beginning and during the outbreak phase, after which this negative impact diminished and the impact during the recession phase of the epidemic was positive.

Conclusions

The ability to prevent and control epidemics and economic development are mutually reinforcing. Economic development strengthens a country's overall strength, allowing a country to have sufficient human, material and financial resources to cope with a widespread epidemic, while strengthening the prevention and control of epidemics is also effective in stopping large-scale epidemics from occurring. The impact of this outbreak on the economy is likely to be mitigated. In the aftermath of an outbreak, governments should actively invest more, stimulate consumption and reduce tax revenues from key affected industries to keep their economies functioning and minimise losses caused by the epidemic.

References

1. Liu Weidong. The impacts of COVID-19 pandemic on the development of economic globalisation. *Geographical Research.* 2020;39(7):1439–1449. DOI: 10.11821/dlyj020200514.

2. Yu Ziqing, Gospodarik CG. [The impact of COVID-19 on Chinese international trade]. *Aktual'nye problemy nauki XXI veka.* 2021;10:27–33. Russian.

3. Nitsch V. COVID-19 and international trade: evidence from New Zealand. *Economics Letters.* 2022;217:110–627. DOI: 10.1016/j.econlet.2022.110627.

4. Rong Li, Yu Ziqing, Gospodarik CG. Digital economy promotes economic development in the COVID-19 era. *Novaya ekonomika.* 2021;2:249–266.

5. Xiu Xiumei, Jan Guang. [Study of crises' impacts on inbound tourism demand based on ARIMA model. A case study of Lijiang]. *Yannan dili huanjing yanjiu.* 2014;26(4):60–64. Chinese.

6. Wu Lihui, Xia Huali, Ma Da. [A study of the impact of sudden events on tourism in Hubei province – an analysis based on the demand for inbound tourism]. *Dangdai jingji.* 2018;13:78–80. Chinese.

7. Hu Ai-Mei, Wang Shuping. [Comparative analysis of the international oil price forecast based on the ARIMA and GARCH models]. *Economic Research Guide.* 2012. Chinese.

8. Wu Zhenxin, Jinyu Jing, Wang Shuping. [Analysis of the impact of strikes by oil workers on the international oil price]. *Hebei jingmao daxue xuebao.* 2010;31(1):59–62. Chinese.

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