BI Norwegian Business School - campus Oslo

GRA 19703

Master Thesis

Thesis Master of Science

A STUDY ON THE IMPACT CHANNELS OF COVID-19 ON THE RETAIL SALES OF CONSUMER GOODS IN CHINA

Navn:	Yifan Cui, Peiyi Yin

Start:	15.01.2021 09.00
Finish:	01.07.2021 12.00

Master Thesis at BI Norwegian Business School

A STUDY ON THE IMPACT CHANNELS OF COVID-19 ON THE RETAIL SALES OF CONSUMER GOODS IN CHINA

By

Peiyi Yin & Yifan Cui

Supervisor: Tong Zhang

Date of submission: 01.07.2021

Campus:

BI Oslo, Nydalen

Examination code and name:

GRA 19703

Thesis Master of Science

Program:

Master of Science in Finance

Abstract

After the outbreak of coronavirus, the Chinese economy and consumption have been negatively affected. First, our study qualitatively analyses the impact channels of the Covid-19 on consumption. Theoretically, in addition to the direct impact of different levels of lockdown measures on consumption, the Covid-19 also negatively impacts consumption through income effect, wealth effect, and actual purchasing power effect. Secondly, this paper uses macro data to conduct quantitative research. We set the VAR model to analyse the relationship between the consumer price index, lockdown variable, and the total retail sales of consumer goods. What's more, we set a control group to discuss how the lockdown measures may affect consumption.

The result of our Wuhan model shows that there is no short-term relationship between Wuhan's CPI and Wuhan's retail sales of consumer goods. In contrast, the lockdown measures could affect consumption. And Chengdu's model also shows similar results. However, the coefficient of the lockdown variable in Wuhan's model is much higher than the coefficient of lockdown variable in Chengdu's model because of the different lockdown levels in these two cities.

Acknowledgments

This master thesis is written as a final assignment to our Master of Science degree in Finance at BI Norwegian Business School. We would like to give our sincere appreciation and gratefulness to our supervisor Tong Zhang for his excellent guidance throughout the whole process. Without his help, it would not have been possible for us to deliver this demanding project. We also thank BI Norwegian Business School, our significant others, and our families for helping us with resources and support in carrying out this project.

The whole process of accomplishing this thesis has been both challenging and rewarding. We enriched our knowledge database, improved our independent learning ability, and developed a much better understanding of what this master program has prepared us for especially in applied research methodology and various econometrics and finance theories.

Table of Contents

List of Figures

List of Tables

1. Introduction and Motivation

1.1. Introduction

In January 2020, the coronavirus suddenly broke out in Wuhan, China. At the end of January, Wuhan was “close”, and then China initiated a first-level emergency response nationwide. Long-term suspension of work and production has severely impacted economic and social activities, and residents’ consumption has declined precipitously. The average contribution rate of final consumption expenditure to economic growth is about 60% from 2013 to 2019, and it has been the main driving force of economic growth for six consecutive years. However, in March 2020, the total retail sales of consumer goods year-on-year growth rate decreased dramatically to negative 15.8% in China and negative 52.51% in Wuhan.

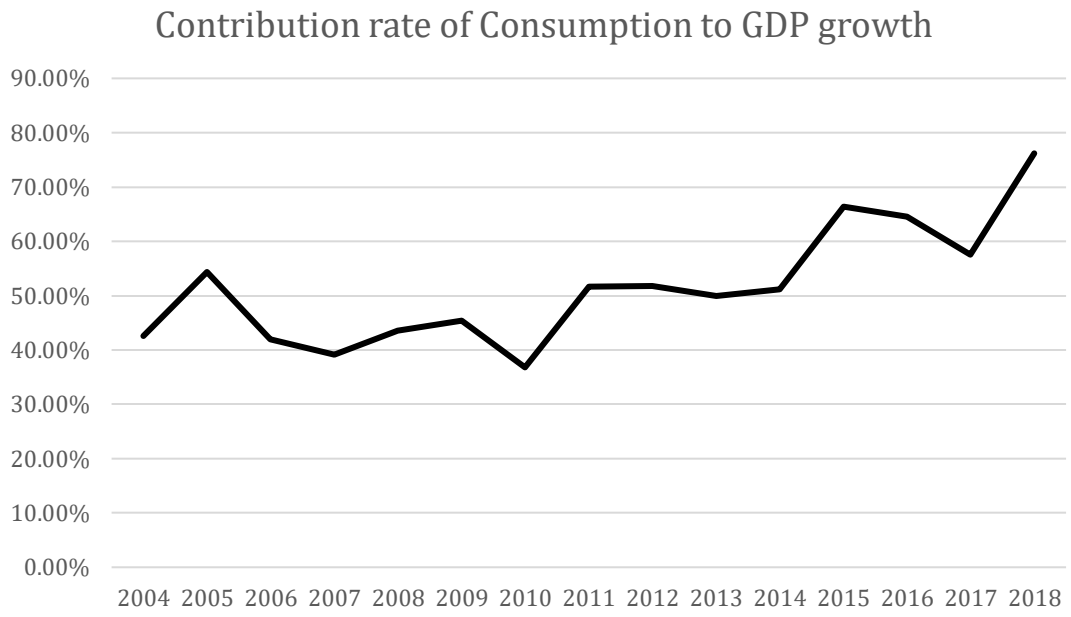


Figure 1.1: Contribution rate of Consumption to GDP growth in China in 2004-2018
Source: Chinese National Bureau of Statistics

In the Economics field, investment, consumption, and export are often called the three main forces that drive GDP growth. Among the three factors, consumption has become more and more important in promoting Chinese economic development. However, the epidemic has caused a severe impact on consumption. Therefore, in this paper, we

apply qualitative theories and use quantitative empirical analysis to identify possible mechanisms about how Covid-19 influences consumption based on total retail sales of consumer goods, which is an important indicator used to reflect the non-production consumption of physical goods in the whole society.

As consumption has become a vital force driving GDP growth, understanding what factors affect consumption is crucial for researchers. In the past, many studies conducted in-depth research on consumption functions and established a literature system including the life cycle theory, the liquidity constraint hypothesis, Etc. Moreover, apart from research about traditional consumption functions, many papers have used empirical studies to examine the relationship between consumption and relevant factors such as the price level and the real estate price index.

However, most of these studies are based on the typical economic and social development environment. Few studies focused on the impact of emergencies on micro-individual economies, and they are mainly about natural disasters. Since the outbreak of covid-19, there have been some papers examining the influence of Covid-19 on consumption, and most of them are based on questionnaires or qualitative analysis focusing on specific industries. Li Liuying, Wu Jiateng (2020) conducted a questionnaire to analyze the following possible impact channels: falling income, uncertainty towards the future, and decreased physical consumption. Thus, we see the importance of analyzing how covid-19 affects consumption represented by the total retail sales of consumer goods through qualitatively studying the underlying economic mechanisms and quantitative empirical models.

1.2. Research objective

Our study reveals the main factors that affected consumption since the outbreak of Covid-19 by qualitatively analyzing different channels that led to the dramatic fluctuations in consumption and, secondly, quantitative identity the relationship between consumption and other main relevant factors using appropriate econometrics models. After the outbreak of Covid-19, many cities have imposed lockdown restrictions in late January. A lot of companies were forced to suspend their production

and operation activities, and people could not physically go outside to consume, which theoretically was in parallel with a rise in the consumer price index (CPI) and a decline in the real estate climate index. Under the empirical analysis,

We discuss the possible mechanisms: consumption declined due to lockdown measures and rising CPI, and the real estate condition may also have an influence on the consumption. To discuss more the effect of lockdown measures on consumption, we also did a robust test using Chengdu's data.

Our paper aims to observe and verify the mechanisms we discussed above and try to explore the relationship between consumption and lockdown measures and changes in CPI.

1.3. Structure of the paper

This paper is organized into seven parts. In Part 1, we will illustrate the importance of consumption in driving GDP growth, the research objective, and why we want to study this specific topic. In Part 2, we will have a literature review covering the studies on consumption function and the relationship between consumption and other factors under both pre and post-pandemic era. Part 3 includes a qualitative analysis of different channels affecting consumption and based on which we come up with our hypothesis tested later under empirical analysis and the variables would be used in our regression. In Part 4, we explain the research methodology we use and the reasons why we choose it. Part 5 would be the data description of variables we used for our analysis. Part 6 is the detailed explanation of our empirical analysis results. Lastly, conclusions are drawn in Part 7.

2. Literature Review

2.1. Literature on classic income & consumption hypothesis

Early research on consumption issued at home and abroad mainly focused on the macro field. In the 1930s, Keynes put forward the absolute income hypothesis, which believed that consumption is a function of current income. Since then, western macroeconomists have conducted in-depth research on consumption functions and established a literature system including life cycle theory, liquidity constraint hypothesis, Etc. Foster John (2018) studied the consumption function focused on the four main approaches: Absolute Income Hypothesis, Relative Income Hypothesis, Life-Cycle Hypothesis, and Permanent Income Hypothesis and a combination of those four approaches.

According to Keynes's Absolute Income Hypothesis, consumption is proportional to current income within the short term. On the one hand, the marginal propensity to consume is influenced by disposable income; the lower-income level of residents, the higher marginal propensity to consume (Chen Binkai, 2012). On the other hand, the increased uncertainty towards future income and lower consumer confidence could decrease the marginal propensity to consume (Luo Zuoyan, Liu Chaohui, 2005). However, most of these studies are based on the typical economic and social development environment. There are few studies focused on the impact of emergencies on micro-individual economies, and they are mainly about natural disasters. Although the new COVID-19 epidemic was an emergency, it is still different from natural disasters. It is manifested in a broader range and is a more sustained threat to life and health.

2.2. Literature regarding consumption on pre-epidemic era

Before the outbreak of Covid-19, there have been many papers examining the relationship between consumption and relevant factors such as the price level and the real estate price index. From a macro perspective, Liao Bin (2014), based on the "Output - Price" Phillips curve combined with the data of CPI, GDP, and growth of consumption to conducting a quantitative analysis of the important factors that affect

the price level and attempt to reveal the relationship between price level, economic growth and consumption level, leading to the conclusion that price changes are affected by the lagging periods of the consumption level.

Liao Xiangyue and Pan Aimin (2008) selected economic indicators such as China's real estate price index, consumer price index, and production material price index from 1998 to 2006, using cointegration analysis and Granger causality test to analyze the relationship between changes in the real estate price and changes in the overall price level. Empirical evidence showed that there is a certain long-term relationship between changes in the real estate price and the general price level. However, this relationship is one-way, meaning that real estate price changes are the Granger cause of the general price level changes. The general price level changes are not the Granger cause of real estate price changes.

Zhang Rong, Zhang Caiqin (2015) found a long-term stable equilibrium relationship among the housing price index, CPI, and the consumption level by using the Vector Autoregression Model. To be more specific, according to impulse response analysis, it is believed that the rise and fall of housing prices have been affected by the positive impact of rising prices in the short term. However, in the long run, it has a significant negative effect. On the contrary, the impact of the housing price index on prices is a continuous positive impact. This is because of the effect of anticipation; the increase in housing prices will bring about an increase in the prices of other commodities.
Additionally, the response of consumption level to price fluctuations is not significant, but the response to price fluctuations continues to be positive. Furthermore, variance decomposition’s results indicated that CPI fluctuations are mainly due to the fluctuations of the house price index. On the contrary, the fluctuations of the house price index are affected by the fluctuations of the CPI and increase over time. The volatility of consumption is affected by the fluctuation of the price index, which becomes more extensive and more significant over time.

2.3. Literature regarding consumption on post-epidemic era

Since the outbreak of COVID-19, there have been some papers examining the influence of COVID-19 on consumption. For example, Yang Yang and Yang Guiyuan (2020) predict the total retail sales of consumer goods in China from January to March in 2020 based on different models. The predicted results show that the total retail sales of consumer goods in January-February 2020 will drop by 25.30% compared with the normal year due to the impact of COVID-19. It was close to the level of the same period of the previous year in May, and in June, it reached or exceeded the level of the same period of the previous year. Besides, some studies showed the impact channels of the epidemic on residents' consumption. The epidemic influences consumption through three channels: falling income reduces consumption willingness and spending power; the wealth effect due to changes in the housing and stock markets; the actual purchasing power effect due to price changes (Fu Zhihua, Wang Zhigang, 2020). Another research based on a questionnaire to analyze the impact channels: devalued effect due to falling income; uncertainty towards future makes residents generate and strengthen preventive savings motives; increased awareness of rational consumption; decreased physical consumption due to safety consideration and lockdown (Li Liuying, Wu Jiateng, 2020).

Wuhan has implemented the strictest personal travel control and has locked down the entire city during the epidemic. From the perspective of urban residents' shopping and entertainment travel modes, Shan Zhaoran (2020) applied travel survey data to prove that Wuhan travel control has significantly reduced people's travel in the area.

2.4. Literature on SARS's influence on consumption

Because it has been only one year since the breakout of COVID-19, there are not many relevant papers for the specific consumption area yet. However, there are many papers about how SARS in 2003 affected the Chinese economy and consumption. Zheng Jianghuai, Fu Yifu, and Tan Jin (2020) reviewed the macroeconomic and consumption situations before and after SARS and compared the new COCID-19 epidemic with the SARS to analyze the potential impact of the new epidemic on the consumption. The paper has shown that in the short term, the impact of the new COVID-19 epidemic on

the macroeconomy is more significant than that of the 2003 SARS epidemic, and it will inevitably cause a shrinking short-term consumption and investment demand, as well as shrinking industrial production activities. However, in the long run, China's economy is stable and improving, and the epidemic's impact can be controlled in the first half of the year.

The above papers all give conclusions or use research methods with reference significance. However, most existing studies focused on changes in consumption in the post-epidemic era are based on questionnaires or qualitative analysis focusing on specific industries. Here we plan to analyze how covid-19 affects consumption that was represented by the total retail sales of consumer goods both through qualitatively studying the underlying economic mechanisms and quantitatively using empirical models.

3. Theory and Hypothesis

3.1. Theory

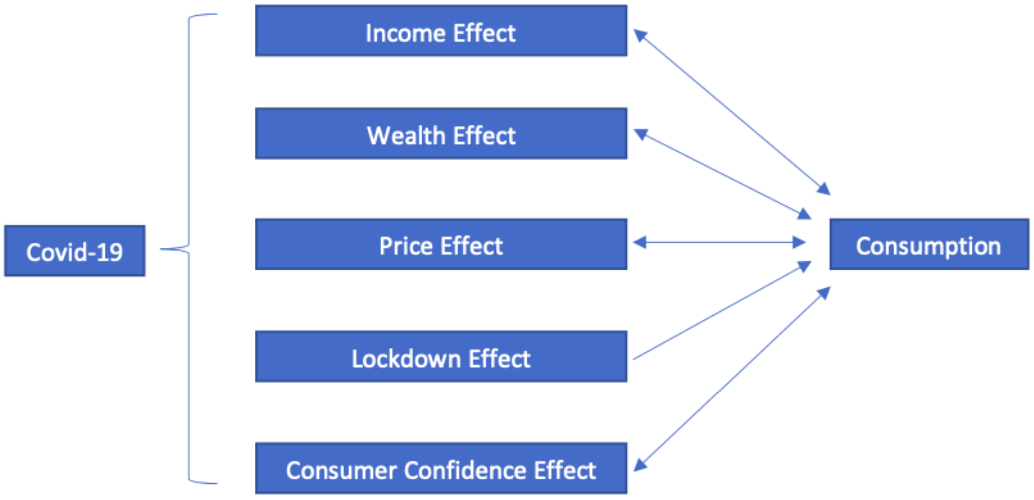


Figure 3.1: The five main channels influencing consumption in the post-epidemic era

The spread of Covid-19 could potentially have many different channels to influence the consumption level. Here we quantitatively analyze the relationship between consumption and the five main factors. The first is the income effect caused by employment changes. The epidemic is mainly spread through the movement of people. Therefore, after the outbreak of Covid-19 in Wuhan at the end of February, different lockdown measures have been adopted throughout China, and population mobility is restricted. Many companies and enterprises have to face increased costs, reduced demand, and reduced profits. Furthermore, they lack the ability to deal with risks. In order to save costs or adapt to the downsizing of the company, the company may choose to lay off employees and then lead to an increase in the unemployment rate and decrease in per capita income. According to data, the unemployment rate in the urban survey in February 2020 was 6.2%, compared with 5.3% in January. As explained in Keynes's Absolute Income Hypothesis, consumption is proportional to current income within the short term. The marginal propensity to consume is influenced by disposable

income; the lower-income level of residents, a higher marginal propensity to consume (Chen Binkai, 2012).

The second is the wealth effect of changes in the real estate market and the stock market. The housing market and stock market decline caused by the epidemic will reduce people's wealth, leading to reduced consumption. Regarding the housing market, the transaction volume of the real estate market in severely affected areas may be affected, and the value of housing may decline. The changes in the sales prices of commercial housing in 70 large and medium-sized cities announced by the National Bureau of Statistics show that in January 2020, whether it is new or second-hand housing, the number of cities whose sales prices have risen month-on-month has decreased. However, due to the more tremendous downward pressure on the economy, real estate control policies in some areas have been loosened, which may help boost housing prices in cities. Moreover, for the stock market, in the early stage of the epidemic, around late January, the panic about the epidemic weakened investor confidence and caused the stock market to fall. Later, as the understanding of the epidemic deepened and the Covid-19 situation improved, the stock market rebounded gradually.

The third is the actual purchasing power effect caused by price changes. Briefly, the rising prices could lead to a decline in purchasing power, leading to a decline in consumption. In order to reduce the risk of the spread of epidemics, some places have adopted measures such as road closures and traffic restrictions. These measures have disrupted production and transportation networks and reduced the effectiveness of the supply and demand structure. Specifically, the unpredictable epidemic has sharply increased the demand for medicines and daily consumer goods in some areas, which will increase prices for these goods and weaken people's actual purchasing power, especially for low- and middle-income groups. According to the data released by the National Bureau of Statistics on February 10, 2020, the CPI in January rose 5.4% year-on-year.

The fourth is the lockdown measures imposed by the government. Home isolation measures in severely affected areas prevent people from going out shopping. Furthermore, for safety reasons, people who live in areas with loose lockdown

measures also avoid going to crowded places like shopping malls, leading to a decline in consumption.

The last one is the decline in consumer confidence in the future economy. The epidemic outbreak may trigger their inner anxiety about the uncertainty of the future, generating family precautionary savings motives. People then tend to reduce consumption and increase savings to cope with additional and large expenditures when uncertain events occur.

The above five influence channels are not only entangled with each other. Their relationship with consumption also affects both ways except for lockdown, a mandatory regulation imposed by the government. Lockdown would not only limit offline consumption but also lead to businesses shutdown, even bankruptcy in some cases, causing declined income levels and shrinking wealth through the stock market and the housing market. What is more, since lockdown blocked the connection between supply and demand, the actual purchasing power would be affected by price changes. The intertwined relationship among the five factors and the two-way influence between them and the consumption caused us to choose the Vector Autoregression Model (VAR Model) instead of a more straightforward Time Series Regression Model in Part 6 Empirical Analysis.

3.2. Hypothesis

The purpose of this paper is to study the impact of changes in the consumer price index on the retail sales of consumer goods, including whether the changes between the two are related and how they may be related. Moreover, we also plan to analyze some other underlying influence channels of the COVID-19 epidemic on residents' consumption based on other theories.

As we described in the 'Theory' part, we discussed several channels that may affect the total retail sales of consumer goods during the Covid-19 epidemic. Because these channels may to some extent affect each other, if we include all factors in our regression, that may impose multicollinearity, leading to specious regression results, and it is not

easy to distinguish the specific impact of each factor on consumption. For instance, the measures of lockdown could affect people's income during the lockdown period. Therefore, in the empirical analysis, we focus on lockdown and the consumer price index to examine the complex relationship between them and the total retail sales of consumer goods.

Our hypothesis is that lockdown and increasing consumer price index are related to decreased total retail sales of consumer goods. In the empirical model, first, we would run regressions based on Wuhan's data. Our hypothesis of the results is that the coefficient of the consumer price index would be statistically significant. Furthermore, we would add the lockdown dummy to see if the lockdown measures are related to the changes in consumption. Moreover, our hypothesis for this is that the coefficient of lockdown measures would be statistically significant, meaning that the lockdown measure in Wuhan is related to the change of consumption. Besides, we add the real estate climate index into the regression to partly cover the wealth effect.

4. Methodology

4.1. Method

As mentioned in the 'Theory' part, the first part of the research is to discuss the possible transmission mechanisms of the epidemic's impact on the retail sales of consumer goods. Furthermore, we plan to mainly study the relationship between the two variables, lockdown and consumer price index, and the retail sales of consumer goods. Moreover, we plan to use the method of setting up a control group to observe the relationship of lockdown policy, consumer price index, and total retail sales of consumer goods and observe and discuss the difference of the relationships in two very similar cities-Wuhan and Chengdu during the COVID-19.

The first step is to find a control group. Here we choose Chengdu as our control group with reasons explained in the following 4.1.2. part, from which we compare the relevant data of Wuhan and Chengdu both before and after the outbreak of Covid-19. For example, we compare the changes in the total retail sales of consumer goods between the two cities before and after the outbreak of the COVID-19 epidemic, and we compare the two cities based on some other aspect such as their development model. Then we discuss possible reasons for the differences during Covid-19 between the two through qualitative analysis.

Then we plan to build the VAR model based on our data sets since the dependent variable and the independent variables are intercorrelated. For example, some previous studies (Liao Bin, 2014) stated that consumption might have a reverse effect on the consumer price index.

4.1.1. VAR, ADF, Granger causality, Impulse response

The autoregression model (VAR) is a model based on the statistical properties of the data. The VAR model takes each endogenous variable in the system as a function of the lag value of all endogenous variables in the system to construct the model, thereby extending the univariate autoregressive model to the vector autoregressive model composed of multiple time series variables. The VAR model is the efficient model to

handle the analysis and prediction of multiple related economic indicators. Therefore, the VAR model has been increasingly applied to the economic and financial fields in recent years. Furthermore, the VAR model is often used to predict the dynamic impact of interrelated time series systems and random disturbances on the variable system, thereby revealing the impact of various economic shocks on the formation of economic variables. Since the variables we chose to study their impact on consumption are intercorrelated, we chose to use the VAR model instead of an alternative multivariate time series regression model.

Because we use time-series data in the model, before conducting the VAR model, it is essential to make sure our time series is stationary. If the variables are not stationary, then it can be proved that the standard assumptions for asymptotic analysis will not be valid. In other words, the usual t-ratios will not follow a t-distribution, so we cannot validly undertake hypothesis tests about the regression parameters. Thus, firstly we use the Augmented Dickey-Fuller (ADF) test to determine whether our variables are stationary or not. The null hypothesis for the ADF test is that a unit root is present in the time series variable. If we reject the null hypothesis, then the variable is non-stationary, and we apply the first difference to the time series and check whether the first differenced time series would be stationary or not.

An important issue in the VAR model is the determination of the lag order. When choosing the lag order, on the one hand, we want to make the order large enough to reflect the dynamic characteristics of the constructed model fully. On the other hand, the larger the lag order, the more parameters need to be estimated, the less the degree of freedom. Therefore, when selecting, the above two aspects are considered comprehensively, and there must be a sufficient number of lag terms and a sufficient degree of freedom. There are two main test methods to determine lag order, using cross-equation restrictions and information criteria. In the following empirical analysis, we choose the optimal lags based on Akaike Information Criterion and Hannan–Quinn information criterion.

In practical applications, because the VAR model does not require any explicit constraints on the variables. Therefore, when analyzing the model, it is often not to

analyze how one variable affects another variable but to analyze the dynamic effect on the system when the model is subjected to a certain shock. This analysis method is called the Impulse response function. Impulse responses trace out the responsiveness of the dependent variables in the VAR to shocks to the error term. Then, a unit shock is applied to each variable, and its effects are noted.

Because Some of the economic variables are significantly correlated, however, they may not all be meaningful. An important application of the VAR model is to analyze the causal relationship between economic time series using the Granger causality tests, which seek to answer questions such as "Do changes in X1 cause changes in X2?" If X1 causes X2, lags of X1 should be significant in the equation for X2. If this is the case, we say that X1 "Granger-causes" X2. If X2 causes X1, lags of X2 should be significant in the equation for X1. If both sets of lags are significant, there is "bi-directional causality".

4.1.2. Chengdu as a control group

In this part, we discussed why our research chose Chengdu as the control group.
Both Wuhan and Chengdu are new first-tier cities in China, and both are vice-provincial cities according to their administrative level. Wuhan is the largest city in the central region, and Chengdu is the largest city in the western region. Therefore, these two cities have lots of similarities.

First, and the most related aspect, Wuhan's and Chengdu's CPI are always very similar, and usually, they move in the same direction. What's more, the total retail sales of consumer goods of both cities are also very close.

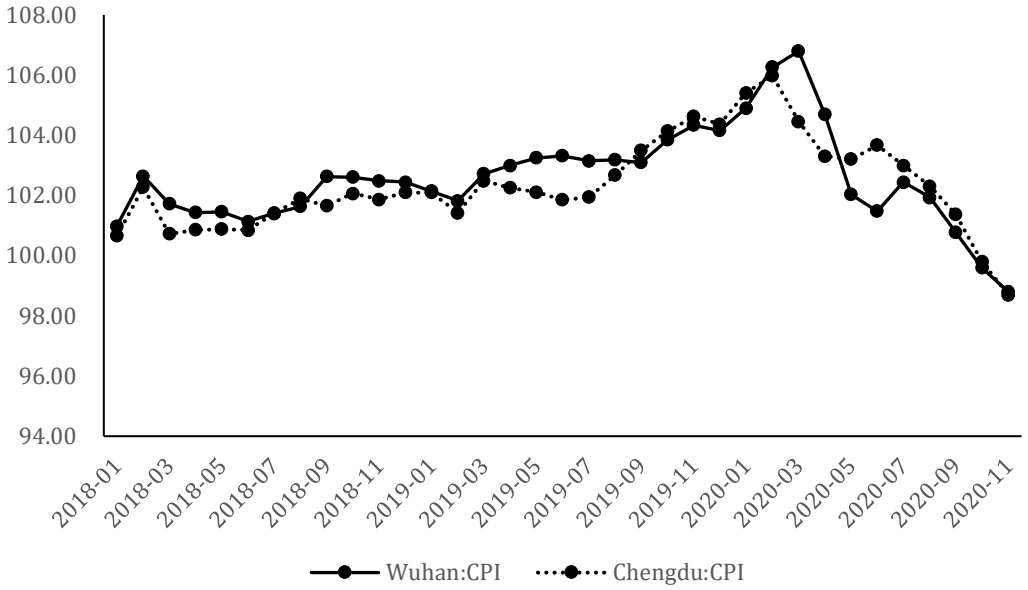


Figure 4.1: The line chart comparison of CPI between Wuhan and Chengdu, from January 2018 to November 2020, containing the time period before and after the Covid-19 breakout. CPI is the variable we select to analyze the price effect mentioned in the 4.1 Method part.

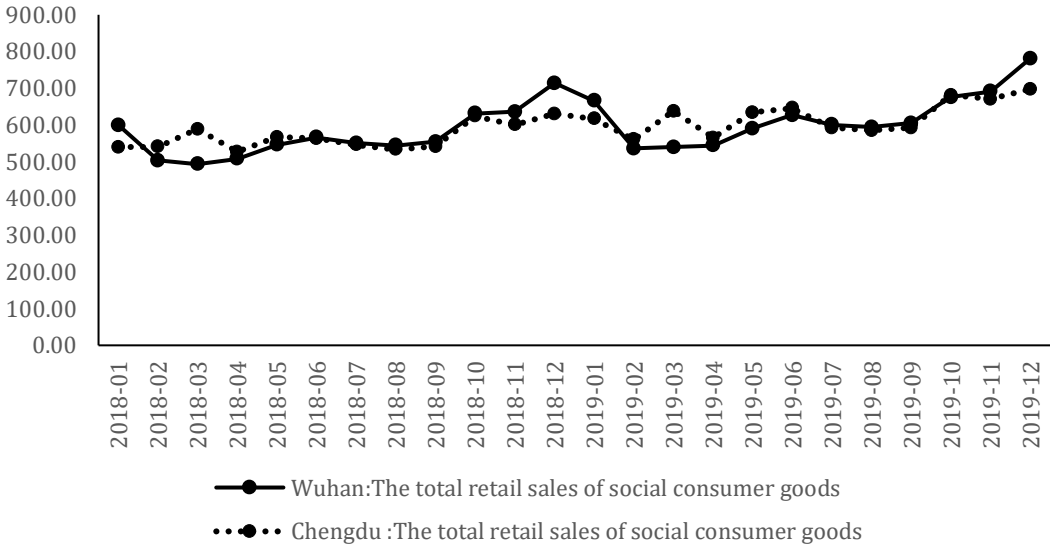


Figure 4.2: The line chart comparison of the total retail sales of consumer goods between Wuhan and Chengdu from January 2018 to December 2019, containing the time period before the Covid-19 breakout. The total retail sales of consumer goods are used to represent our research objective, the consumption level.

	CPI (Wuhan)	CPI (Chengdu)	The total retail sales of consumer goods (Wuhan)	The total retail sales of consumer goods (Chengdu)
Mean	102,53	102,11	595,56	595,00
Minimum value	100,98	100,66	493,18	527,10
Maximum value	104,34	104,62	780,87	697,50
Standard deviation	0,94	1,10	71,83	49,31

Table 4.1: Summary statistics for comparing the consumption level represented by the total retail sales of consumer goods and the price level represented by CPI between Wuhan and Chengdu, which is our control group.

We can see from Figures 2 and 3 that the CPI and total retail sales of consumer goods in Wuhan and Chengdu from 2018 to 2019 are similar. From table 1, the mean of CPI and the mean of total retail sales of consumer goods between the two cities are very similar before the breakout of COVID-19. One major difference between these two cities is that Wuhan's total retail sales of consumer goods have a more significant standard deviation than that of Chengdu. What's more, the number of permanent residents in Chengdu and Wuhan is also relatively close. The price level in Chengdu is slightly lower than that in Wuhan, and the per capita disposable income is also slightly lower. Therefore, we selected Chengdu as the control group of Wuhan to observe the difference in the impact of the total retail sales of consumer goods in the two cities after the outbreak began.

Wuhan and Chengdu have very similar economic aggregates. In 2018, Chengdu's GDP was 1,534.277 billion, and Wuhan's GDP was 1,484.729 billion, ranking eighth and ninth in the country, respectively. By coincidence, Sichuan's GDP in 2018 was 4.067813 billion, and Hubei's GDP was 3.936655 billion. Chengdu and Wuhan GDP both accounted for 37.72% of their province, respectively.

This also leads to the similarities between the two cities' development models. There are many indicators to measure the strength of a provincial capital city, such as GDP, population, capital, and the ratio of the city with the largest GDP among non-provincial capital cities, etc. However, no matter from which point of view the weight of a

provincial capital city in the province is measured, it cannot be separated from the GDP dimension. Both Wuhan and Chengdu account for more than 30% of GDP in their provinces. This indicates that the urban primacy for Wuhan and Chengdu is high. At the same time, the two cities have always been considered representatives of strong provincial capitals.

4.2. Regression Variables

As discussed in Part 3 Theory and Hypothesis, there are five main channels that have influenced consumption since the epidemic broke out: income effect, wealth effect, price effect, lockdown effect, and consumer confidence effect. Since the above relevant variables are intercorrelated, we could not insert all variables in a regression. Otherwise, that would cause serious multicollinearity problems. Therefore, in our study, we choose to mainly focus on the income effect and the lockdown effect, which require the regression variables to be the consumer price index and an ordinal categorical variable representing lockdown, which is divided into three levels, equals to 2 for a period with strong lockdown measures in that time period, 1 for a period with weak lockdown measures, and 0 for a period without lockdown measures. Besides, given the significance of the housing market in China, we also add the retail estate climate index as a control variable in the VAR model.

5. Data

5.1. Data collection

We plan to collect monthly data on total retail sales of consumer goods, the consumer price index (CPI), and the real estate index. The estimated period is from January 2020 to the latest data at the beginning of our modeling. All data come from the National Bureau of Statistics of China database. The data of the cities come from the Statistics Bureau of Sichuan Province and Hubei Province and the Wind database.

5.2. Sample description

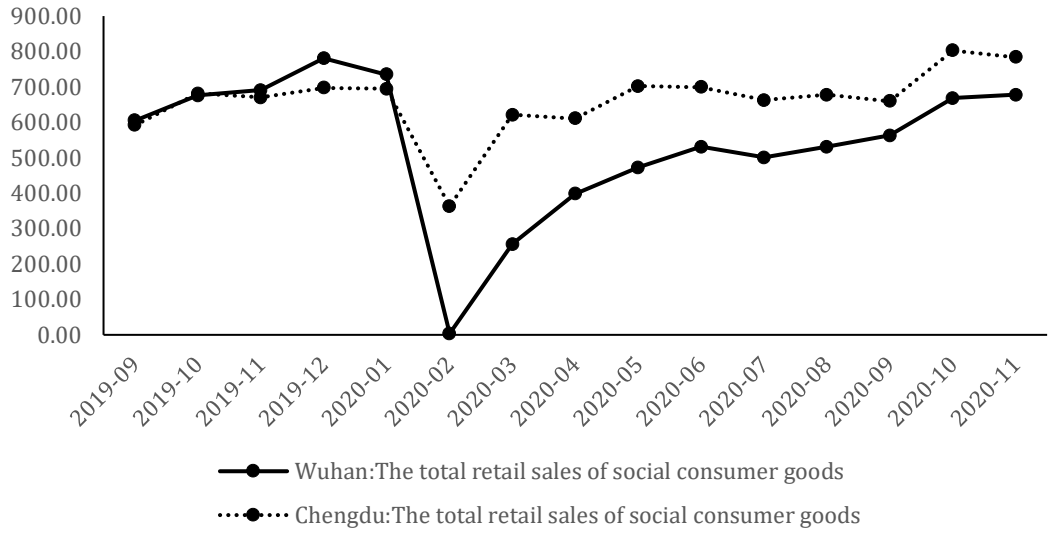


Figure 5.1: The line chart comparison of the total retail sales of consumer goods between Wuhan and Chengdu from September 2019 to November 2020, containing the period before and after the Covid-19 breakout. The total retail sales of consumer goods are used to represent our research objective, the consumption level.

Since the outbreak of Covid-19 in Wuhan at the end of January, the total retail sales of consumer goods in Chengdu and Wuhan have experienced a sharp decline and a gradual recovery. However, from Figure 5.1, it is clear that Wuhan has been more affected in February, and the rate of recovery has been slower. The above phenomenon may be because Wuhan's lockdown policy is more substantial and lasts longer than Chengdu's lockdown policy. It can be seen from the data line chart that the total retail

sales of consumer goods in Wuhan dropped sharply to 0.37 billion yuan in February. Then it gradually recovered to 67.748 billion yuan in November.

The main objective of this study is to examine the relationship between the two independent variables, lockdown and consumer price index, and the retail sales of consumer goods. Furthermore, we plan to set up a control group to observe the relationship between lockdown policy, consumer price index, and total retail sales of consumer goods in Chengdu, meanwhile observing and discussing the difference of the relationships in the two very similar cities-Wuhan and Chengdu during the COVID-19. Before conducting a quantitative VAR model, in this section, we want to see the linear relationship between the consumer price index and the retail sales of consumer goods, and the linear relationship between real estate climate index and the retail sales of consumer goods in both Wuhan and Chengdu.

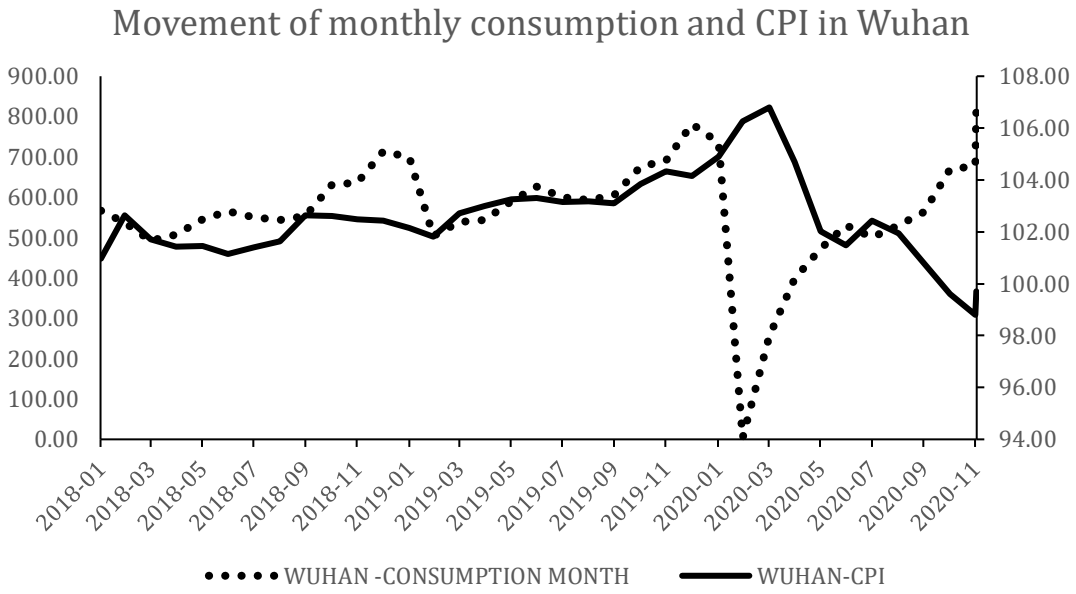


Figure 5.2: The line chart comparison between Wuhan's total retail sales of consumer goods and Wuhan's consumer price index. In the following VAR model in the empirical analysis, the former one is our research objective representing the consumption level and is the dependent variable in equation (4). The latter one is one of the main effect channels which influences the consumption that we want to study and serves as an independent variable in equation (4).

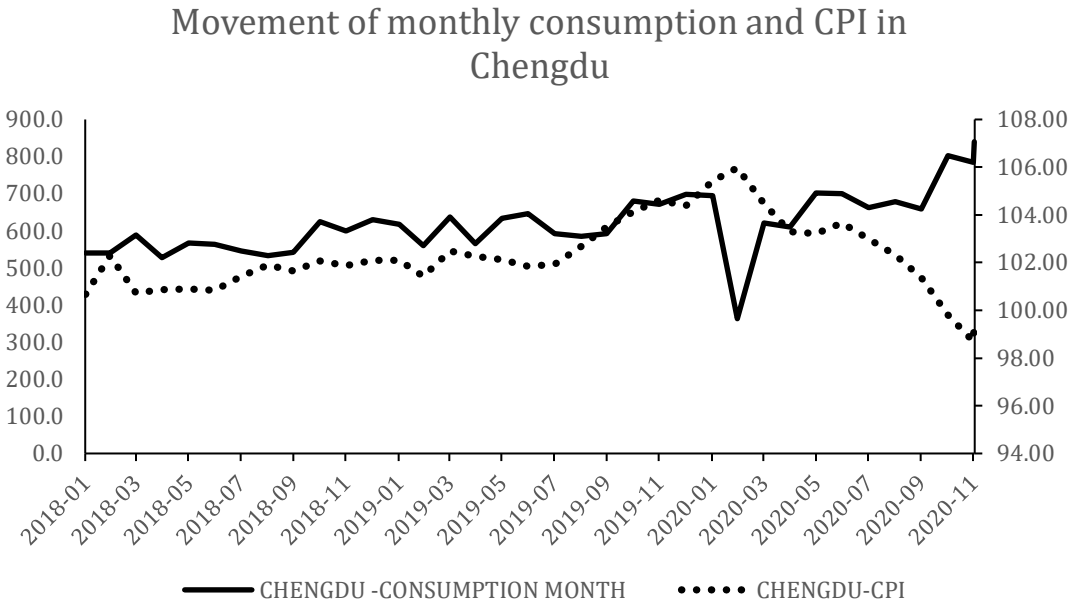


Figure 5.3: The line chart comparison between Chengdu's total retail sales of consumer goods and Chengdu's consumer price index. They are the main variables in the controlled experiment in the following empirical analysis.

Figure 5.2 and Figure 5.3 show that the relationship between CPI and the retail sales of consumer goods in Wuhan and Chengdu have similar patterns. In both cities, the total retail sales of consumer goods experienced a sharp decline in February 2020 and then a gradual recovery, while CPI showed a sudden rise in February 2020 and then a gradual decline afterward. The difference between the two cities is that in February 2020, the decline of the total retail sales of consumer goods and the rise of CPI were more substantial in Wuhan than in Chengdu.

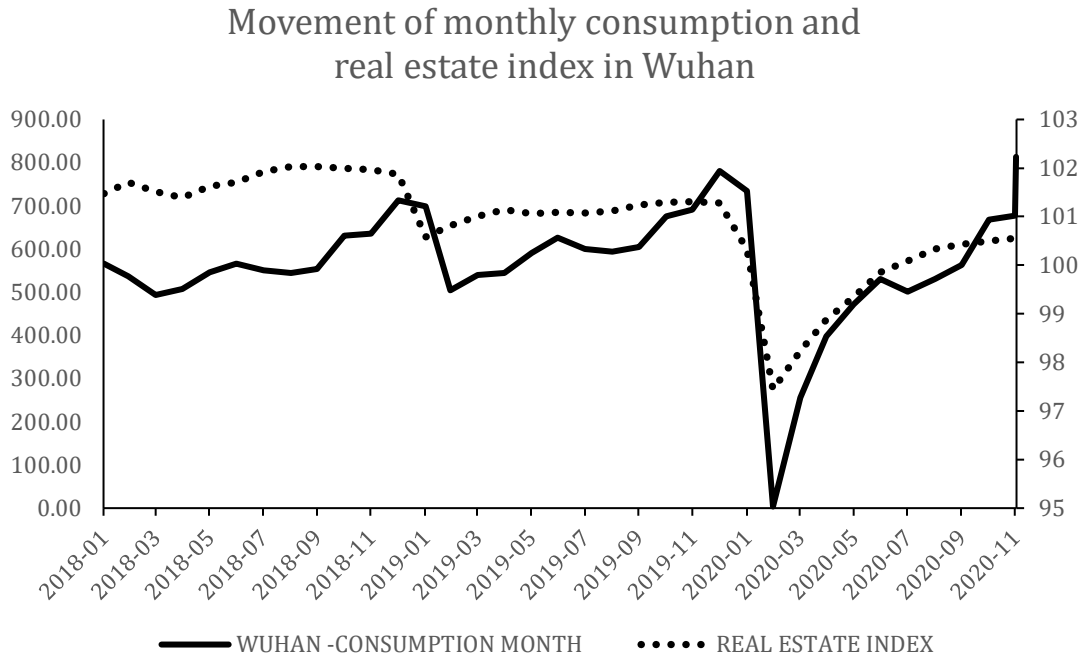


Figure 5.4: The line chart comparison between Wuhan's total retail sales of consumer goods and Wuhan's real estate climate index. In the following VAR model in the empirical analysis, the former one is our research objective representing the consumption level and is the dependent variable in equation (4). The latter one is a control variable to cover the wealth effect partially.

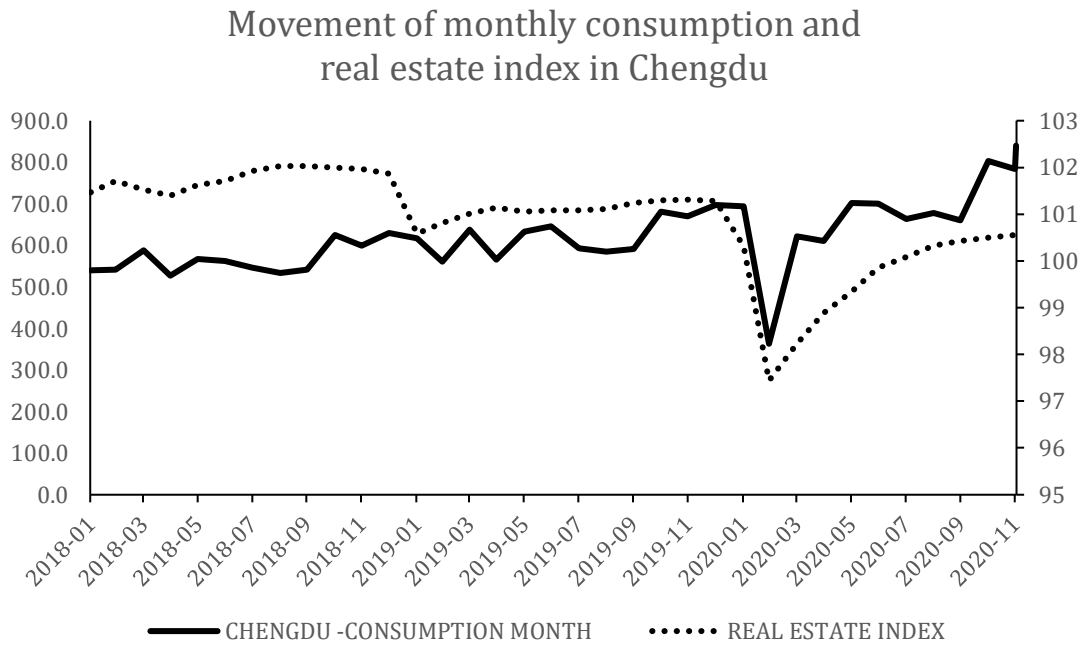


Figure 5.5: The line chart comparison between Chengdu's total retail sales of consumer goods and Chengdu's real estate climate index. They are the variables in the controlled experiment in the following empirical analysis.

We plotted the relationship between the real estate climate index and the retail sales of consumer goods in Wuhan and Chengdu. Figure 5.4 and Figure 5.5 show that they also have similar patterns: the real estate climate index decreased with the decline of retail sales of consumer goods.

As the first outbreak of the epidemic and the city suffered the most, Wuhan's retail sales showed a subtle decline in December 2019 and then a dramatic decrease in February 2020. Our control group, Chengdu's first decrease of the retail sales of consumer goods due to Covid-19, was later than in Wuhan, coinciding with the sharp decrease in Wuhan in February 2020. In Wuhan, the real estate climate index decreased simultaneously with the retail sales of consumer goods. While in Chengdu, the real estate index decreased earlier than the retail sales of consumer goods. The above difference is because we collected the national real estate climate index, reflecting the housing market nationally. The decrease in the retail sales of consumer goods in December 2019 in Wuhan might contribute to the decline of the national real estate climate index.

6. Empirical Analysis

6.1. Time series with stationarity - Wuhan

The first step before building a model is to check whether each time series variable is stable to avoid spurious regression. Our research uses the Augmented Dickey-Fuller test to check the stationarity of time series variables in the VAR model. The test's null hypothesis is that the H0: the tested variable is a non-stationary time series with unit roots. For the series that accepts the null hypothesis, the time series variables contain unit roots. We perform the first difference of these time series and then test their stationarity again to see if it is stable after the first difference.

The following table shows the results of the ADF test on time series variables in our model, including the consumer price index of Wuhan and Chengdu, the first difference of the consumer price index of Wuhan and Chengdu, the total retail sales of consumer goods in Wuhan and Chengdu, the real estate climate index, and the first difference of the real estate climate index.

Variable	ADF statistic	Significance Level			p-value	Result
		1%	5%	10%		
WHcon	-5,131	-3,682	-2,972	-2,618	0,000	reject H0
WHCPI	-1,265	-3,682	-2,972	-2,618	0,645	accept H0
REI	-1,782	-3,682	-2,972	-2,618	0,390	accept H0
CDCPI	-1,117	-3,682	-2,972	-2,618	0,708	accept H0
D_WHCPI	-4,343	-3,682	-2,972	-2,618	0,000	reject H0
D_CDCPI	-5,442	-3,682	-2,972	-2,618	0,000	reject H0
D_REI	-4,962	-3,682	-2,972	-2,618	0,000	reject H0

Table 6.1: The results of the ADF test for checking the stationarity of the time series variables in our VAR model. The null hypothesis is that the tested variable is a non-stationary time series with unit roots. We get results about whether to reject the null hypothesis or not based on the p-value.

From the results shown in the above table, it can be seen that the Wuhan and Chengdu's consumer price index (WHCPI and CDCPI) and the real estate climate index (REI) are all non-stationary series with unit roots; the time series of Wuhan and Chengdu's total retail sales of consumer goods are stationary series without unit roots. For non-

stationary variables, we apply the first difference and then use the ADF test to check again whether the first differenced variables are stationary or not. The results indicate that the first differenced consumer price index in Wuhan and Chengdu and the real estate climate index convert to stationary. Thus, they are the time series that will be used in the following VAR model.

6.2. Models' lag period and model stability - Wuhan

In this section, the VAR model of the total retail sales of consumer goods, the consumer price index, the real estate climate index, and the city lockdown policy variable (set as an ordinal categorical variable) is established to study their interrelationships. We mainly study the effects of the latter three variables made on the total retail sales of consumer goods.

First, we need to determine the optimal lag order of the VAR model and test the stability of the model. As shown in Table 6.2, we establish a VAR (2) model of total retail sales of consumer goods, consumer price index, real estate climate index, and city lockdown policy based on the AIC, HQIC, and FPE statistics.

Akaike's Information Criterion (AIC): Choosing the p that minimizes the following

$$AIC(m) = ln|\Sigma_u(m)| + 2mK^2/T \quad (1)$$

Hannan-Quinn Criterion (HQIC): Choosing the m that minimizes the following

$$BIC(m) = ln|\Sigma_u(m)| + (2\ ln\ ln\ T/T)\ mK^2 \quad (2)$$

Final Prediction Error (FPE): Choosing the m that minimizes the following

$$FPE(m) = [(T + Km + 1)/(T - Km - 1)]^K\ det\ \Sigma_u(m) \quad (3)$$

Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	-102,237		16		0,178	6,789	6,835	6,928
1	-84,806	34,862	16	0,000	0,104	6,246	6,427	6.800*
2	-70,033	29.546*	16	0,001	0.073*	5.873*	6.190*	6,845
3	-63,792	12,483	16	0,187	0,092	6,051	6,503	7,439

Table 6.2: The results of choosing the optimal lag orders in the VAR model using STATA. We select the optimal lag numbers based on FPE, AIC, and HQIC.

Next, the stability test of the characteristic roots of the model is performed. As shown in Table 6.3, all the characteristic roots of the variables are less than 1, and all the characteristic roots in Figure 6.1 are in the unit circle. Therefore, it is determined that the VAR (2) model is stable.

	Eigenvalue		Modulus
dWHcon			
L1	-0,5556	0,5767	0,8008
L2	-0,5556	-0,5767	0,8008
dWHCPI			
L1	0,5626	0,5288	0,7721
L2	0,5626	-0,5288	0,7721
dREI			
L1	0,1465	0,6610	0,6770
L2	0,1465	-0,6610	0,6770
Lockdown			
L1	0,6164		0,6164
L2	-0,4050		0,4050

Table 6.3: The stability test results for the first lag and second lag of all the time series variables in the VAR model. L1 means the first lag, and L2 means the second lag. Since all the variable lags' modulus are less than 1, it is determined that the VAR model is stable.

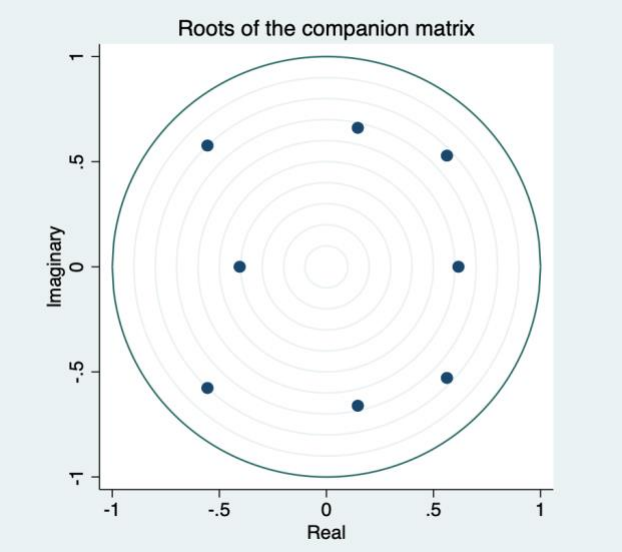


Figure 6.1: Use a graphic to intuitively prove that the VAR model is stable since all the characteristic roots are in the unit circle.

6.3. The VAR model - Wuhan

$$\begin{pmatrix} X_{1t} \\ X_{2t} \\ X_{3t} \\ X_{4t} \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{pmatrix} + \begin{pmatrix} \varphi_{1,1} & \varphi_{1,2} & \varphi_{1,3} & \varphi_{1,4} \\ \varphi_{2,1} & \varphi_{2,2} & \varphi_{2,3} & \varphi_{2,4} \\ \varphi_{3,1} & \varphi_{3,2} & \varphi_{3,3} & \varphi_{3,4} \\ \varphi_{4,1} & \varphi_{4,2} & \varphi_{4,3} & \varphi_{4,4} \end{pmatrix} \begin{pmatrix} X_{1,t-1} \\ X_{2,t-1} \\ X_{3,t-1} \\ X_{4,t-1} \end{pmatrix}$$

$$+ \begin{pmatrix} \varphi_{1,5} & \varphi_{1,6} & \varphi_{1,7} & \varphi_{1,8} \\ \varphi_{2,5} & \varphi_{2,6} & \varphi_{2,7} & \varphi_{2,8} \\ \varphi_{3,5} & \varphi_{3,6} & \varphi_{3,7} & \varphi_{3,8} \\ \varphi_{4,5} & \varphi_{4,6} & \varphi_{4,7} & \varphi_{4,8} \end{pmatrix} \begin{pmatrix} X_{1,t-2} \\ X_{2,t-2} \\ X_{3,t-2} \\ X_{4,t-2} \end{pmatrix}$$

$$+ \begin{pmatrix} u_{1,t} \\ u_{2,t} \\ u_{3,t} \\ u_{4,t} \end{pmatrix}$$

Based on Information Criterion AIC, HQIC, and FPE, the optimal lag of the VAR model is 2. After using the stability test to ensure that the model is stable, we establish a VAR (2) model with four variables. One of them, the lockdown, is an ordinal categorical variable, while the other three are stationary time series variables.

The above VAR (2) matrix formula can also be expressed by the following equations, where X1 means the Total Retail Sales of Consumer Goods in Wuhan, X2 means Consumer Price Index in Wuhan, X3 means the Real Estate Climate Index in Wuhan, and X4 means the Lockdown measures in Wuhan. The lockdown is an ordinal categorical variable entirely determined by government regulations. Thus, equation (7) has no economic meaning, and we will omit equation (7) in the following Granger causality test and Impulse response analysis.

$$X_{1,t} = \alpha_1 + \phi_{1,1}X_{1,t-1} + \phi_{1,2}X_{2,t-1} + \phi_{1,3}X_{3,t-1} + \phi_{1,4}X_{4,t-1} + \phi_{1,5}X_{1,t-2} + \phi_{1,6}X_{2,t-2} + \phi_{1,7}X_{3,t-2} + \phi_{1,8}X_{4,t-2} + u_{1,t} \quad (4)$$

$$X_{2,t} = \alpha_2 + \phi_{2,1}X_{1,t-1} + \phi_{2,2}X_{2,t-1} + \phi_{2,3}X_{3,t-1} + \phi_{2,4}X_{4,t-1} + \phi_{2,5}X_{1,t-2} + \phi_{2,6}X_{2,t-2} + \phi_{2,7}X_{3,t-2} + \phi_{2,8}X_{4,t-2} + u_{2,t} \quad (5)$$

$$X_{3,t} = \alpha_3 + \phi_{3,1}X_{1,t-1} + \phi_{3,2}X_{2,t-1} + \phi_{3,3}X_{3,t-1} + \phi_{3,4}X_{4,t-1} + \phi_{3,5}X_{1,t-2} + \phi_{3,6}X_{2,t-2} + \phi_{3,7}X_{3,t-2} + \phi_{3,8}X_{4,t-2} + u_{3,t} \quad (6)$$

$$X_{4,t} = \alpha_4 + \phi_{4,1}X_{1,t-1} + \phi_{4,2}X_{2,t-1} + \phi_{4,3}X_{3,t-1} + \phi_{4,4}X_{4,t-1} + \phi_{4,5}X_{1,t-2} + \phi_{4,6}X_{2,t-2} + \phi_{4,7}X_{3,t-2} + \phi_{4,8}X_{4,t-2} + u_{4,t} \quad (7)$$

The above equations (4) - (6) are Wuhan's VAR model's equations. We can see from Table 6.4, for equation (4) that represent how independent variables related to the total retail sales of consumer goods in Wuhan, the coefficient of Wuhan's total retail sales of consumer goods (both L1 and L2) are statistically significant, and also the lockdown dummy is statistically significant, meaning that the consumption itself and the lockdown measure may have an impact on the total retail sales of consumer goods in Wuhan, both before and during the covid-19 period. Wuhan's CPI and the real estate climate index are statistically insignificant for equation (4), meaning that Wuhan's CPI and the real estate condition may not affect the total retail sales of consumer goods in Wuhan. Besides, for equation (6), where the dependent variable represents real estate condition, we found that the lockdown may influence the real estate condition.

		Coef.	Std. Err.	t	P>|t|	95%CI	
						LL	UL
dWHcon	Constant	0,035	0,128	0,280	0,785	-0,229	0,300
	dWHcon						
	L1	-2,070	0,252	-8,200	0,000	-2,590	-1,549
	L2	-0,648	0,201	-3,230	0,004	-1,063	-0,234
	dWHCPI						
	L1	0,217	0,223	0,970	0,341	-0,244	0,677
	L2	0,215	0,155	1,390	0,178	-0,105	0,534
	dREI						
	L1	0,554	0,443	1,250	0,224	-0,361	1,468
	L2	-0,298	0,393	-0,760	0,456	-1,109	0,513
	Lockdown						
	L1	-3,223	0,752	-4,290	0,000	-4,774	-1,671
	L2	3,423	0,675	5,070	0,000	2,030	4,816
dWHCPI	Constant	0,091	0,115	0,790	0,440	-0,148	0,329
	dWHcon						
	L1	-0,028	0,227	-0,120	0,903	-0,496	0,440
	L2	0,010	0,181	0,060	0,954	-0,362	0,383
	dWHCPI						
	L1	0,186	0,201	0,930	0,362	-0,228	0,600
	L2	-0,281	0,139	-2,020	0,055	-0,568	0,007
	dREI						
	L1	0,120	0,398	0,300	0,766	-0,702	0,943
	L2	-0,301	0,353	-0,850	0,402	-1,030	0,428
	Lockdown						
	L1	0,552	0,676	0,820	0,422	-0,844	1,948
	L2	-1,242	0,607	-2,050	0,052	-2,495	0,011
dREI	Constant	-0,012	0,087	-0,140	0,892	-0,192	0,168
	dWHcon						
	L1	-0,920	0,171	-5,38	0,000	-1,273	-0,567
	L2	-0,275	0,136	-2,02	0,055	-0,556	0,006
	dWHCPI						
	L1	0,148	0,151	0,980	0,337	-0,164	0,460
	L2	-0,014	0,105	-0,130	0,895	-0,231	0,203
	dREI						
	L1	0,206	0,301	0,690	0,499	-0,414	0,826
	L2	-0,181	0,266	-0,680	0,503	-0,731	0,369
	Lockdown						
	L1	-2,018	0,510	-3,960	0,001	-3,070	-0,966
	L2	2,091	0,458	4,570	0,000	1,146	3,036

Table 6.4: The results for the VAR (2) model in Wuhan. In the leftmost column, dWHcon represents the total retail sales of consumer goods and corresponds with equation (4). dWHCPI represents the consumer price index and corresponds with equation (5). dREI represents the real estate climate index and corresponds with equation (6). Lockdown is an exogenous variable ultimately determined by governmental regulations. Thus, we omit the results for

equation (7), which have no economic meaning. The above table includes the coefficients, standard errors, t-statistics, p-values, and the confidence intervals for equation (4) - (6).

6.4. Granger causality test - Wuhan

We use StataSE16 to perform Granger causality tests on the causality relationships between the total retail sales of consumer goods and the consumer price index, the lockdown variable, the real estate climate index, and the causality between the lockdown variable the consumer price index. The results are shown in Table 6.5.

Equation	Excluded	F	df	df_r	Prob > F
dWHcon	dWHCPI	2,174	2	24	0,135
dWHcon	dREI	1,056	2	24	0,364
dWHcon	Lockdown	13,411	2	24	0,000
dWHcon	ALL	9,067	6	24	0,000
dWHCPI	dWHcon	0,015	2	24	0,985
dWHCPI	dREI	0,405	2	24	0,671
dWHCPI	Lockdown	6,060	2	24	0,007
dWHCPI	ALL	3,103	6	24	0,022
dREI	dWHcon	14,511	2	24	0,000
dREI	dWHCPI	0,506	2	24	0,609
dREI	Lockdown	10,668	2	24	0,000
dREI	ALL	6,130	6	24	0,000

Table 6.5: Results for the Granger causality test. Under the column Equation, dWHcon represents the total retail sales of consumer goods and corresponds with equation (4). dWHCPI represents the consumer price index and corresponds with equation (5). dREI represents the real estate climate index and corresponds with equation (6). Lockdown is an exogenous variable ultimately determined by governmental regulations. Thus, we omit the results for equation (7), which have no economic meaning.

H0	F statistics	p-value	Result
WHCPI is not the Granger Reason for WHcon	2,1754	0,1354	Accept H0
WHcon is not the Granger Reason for WHCPI	0,0153	0,9848	Accept H0
REI is not the Granger Reason for WHcon	1,0560	0,3635	Accept H0
Lockdown is not the Granger Reason for WHcon	13,4110	0,0001	Reject H0
Lockdown is not the Granger Reason for WHCPI	6,0601	0,0074	Reject H0

Table 6.6: The null hypothesis for the causality relationships we are interested in in the study and the results about whether to reject the null hypothesis or not are shown in the table based on its corresponding p-value.

We can see from Table 6.6, for instance, in the Granger causality test between the total retail sales of consumer goods in Wuhan and the Wuhan's CPI, the null hypothesis is that "the total retail sales of consumer goods is not the Granger reason for Wuhan's CPI" and "Wuhan's CPI is not the Granger Reason for the total retail sales of consumer goods." The corresponding p-values are 0.985 and 0.135, respectively, and cannot reject the null hypothesis. Therefore, Wuhan's total retail sales of consumer goods and Wuhan's consumer price index are not Granger's reasons for each other.

As we mentioned, our research mainly focuses on if these variables have any relationship with the total retail sales of consumer goods. The corresponding p-value for the Granger causality test of Wuhan's total retail sales of consumer goods and the real estate climate index is 0.3635, which cannot reject the null hypothesis. While the p-value for Granger test of the Wuhan's total retail sales of consumer goods and the ordinal categorical variable - Lockdown is 0.0001, rejecting the original hypothesis, concluding that the real estate climate index is not the granger reason for Wuhan's total retail sales of consumer goods and that the Lockdown measures in Wuhan are the Granger reason for Wuhan's total retail sales of consumer goods.

Besides, we also found that the p-value for the test between the Wuhan's CPI and Lockdown variable is 0.0074, rejecting the null hypothesis under the 95% confidence interval and means the lockdown is the granger reason for Wuhan's CPI.

6.5. Impulse response analysis - Wuhan

In order to have a deeper understanding of the impact process, our research selects ten months for impulse analysis, and the relationship interesting to us is shown in the following figures.

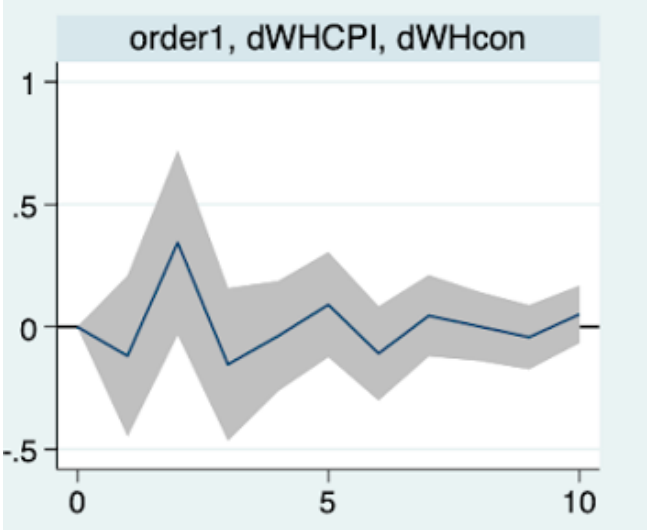


Figure 6.2: The graph comes from the impulse response analysis regarding Wuhan's total retail sales of consumer goods' fluctuations in 10 months after Wuhan's CPI is impacted by one unit standard deviation.

As we can see from Figure 6.2, when Wuhan's CPI is impacted by one unit standard deviation, it has an unstable impact on Wuhan's total retail sales of consumer goods, and the pattern is unclear.

Figure 6.3: The graph comes from the impulse response analysis regarding Wuhan's total retail sales of consumer goods' fluctuations in ten months after Wuhan's lockdown variable is impacted by one unit standard deviation.

As shown in Figure 6.3, when we impose one unit standard deviation impact on the Wuhan's lockdown variable, it has a pronounced negative impact on Wuhan's total

retail sales of consumer goods in the first month and then become a positive impact from the second month and reaches its maximum also in the second month after the impact, then weakens and stabilizes in the fifth month.

Figure 6.4: The graph comes from the impulse response analysis. The left part is about Wuhan total retail sales of consumer goods' fluctuations in 10 months after Wuhan's lockdown variable is impacted by one unit standard deviation, and the right part is regarding Wuhan consumer price index fluctuations in 10 months after Wuhan's lockdown variable is impacted by one unit standard deviation.

According to Figure 6.4, when we give one unit of standard deviation impact on the Wuhan's lockdown variable, it shows an opposite impact on the Wuhan's CPI compared to the impact on the Wuhan's total sales of consumer goods, meaning that firstly was a positive impact and then a negative impact. Moreover, the impact almost disappears around the 10th month.

The results we got from the Impulse response analysis further verified the price effect and the lockdown effect we discussed in Part 3 Theory. After the breakout of Cocid-19, lockdown measures were adopted nationally, which partially disrupted production and transportation networks and reduced the effectiveness of the supply and demand structure, leading to rising price levels represented by the consumer price index and a lower real purchasing power. What is more, lockdown physically prevented people from going out shopping, resulting in decreased consumption levels represented by the total retail sales of consumer goods.

6.6. Robust testing

6.6.1. Models' lag period and model stability - Chengdu

As we explained in Methodology 4.1.2, we choose Chengdu as a control group to conduct a robust test to explore the influence of lockdown on consumption further. Similar to the VAR model we used on Wuhan's data, in this section, we also use the VAR model based on Chengdu's total retail sales of consumer goods, consumer price index, real estate climate index, and city lockdown policy variable (set as an ordinal categorical variable) to study their interrelationships. We mainly study the effects of the latter three variables on the total retail sales of consumer goods and focus on the difference between Wuhan and Chengdu.

First, we need to determine the optimal lag order of the VAR model and test the stability of the model. As shown in Table 6.7, we establish a VAR (2) model of total retail sales of consumer goods, consumer price index, national housing index, and city lockdown policy based on the AIC, HQIC, and FPE.

Lag	LL	LR	df	P	FPE	AIC	HQIC	SBIC
0	-27,528		16		0,000	2,034	2,094	2,219
1	0,830	56,717	16	0,000	0,000	1,237	1,538	2.162*
2	27,254	52,849	16	0,000	0.000*	0.564*	1.107*	2,230
3	33,615	12,722	16	0,693	0,000	1,186	1,970	3,592

Table 6.7: The results of choosing the optimal lag orders in the VAR model using STATA. We select the optimal lag numbers based on FPE, AIC, and HQIC.

Next, the stability test of the characteristic roots of the model is performed. As shown in Table 6.8, all the characteristic roots of the variables are less than 1, and all the characteristic roots in Figure 6.5 below are in the unit circle. Therefore, it is determined that the VAR (2) model is stable.

	Eigenvalue		Modulus
dCDcon			
L1	0,4665	0,1634	0,4943
L2	0,4665	0,1634	0,4943
dCDCPI			
L1	0,2951	0,3429	0,4524
L2	0,2951	0,3429	0,4524
dREI			
L1	-0,1761	0,4048	0,4414
L2	-0,1761	0,4048	0,4414
Lockdown2			
L1	-0,6415		0,6415
L2	-0,1944		0,1944

Table 6.8: The stability test results for the first lag and second lag of all the time series variables in the VAR model. L1 means the first lag, and L2 means the second lag. Since all the variable lags' modulus are less than 1, it is determined that the VAR model is stable.

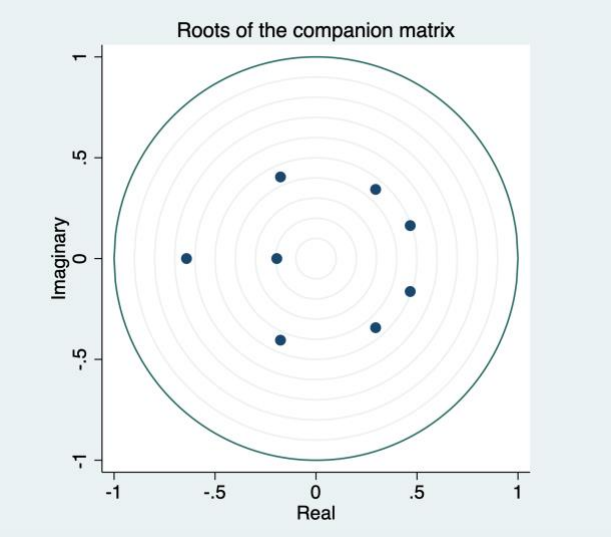


Figure 6.5: Use a graphic to intuitively prove that the VAR model is stable since all the characteristic roots are in the unit circle.

6.6.2. The VAR model - Chengdu

$$\begin{pmatrix} Y_{1t} \\ Y_{2t} \\ Y_{3t} \\ Y_{4t} \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \end{pmatrix} + \begin{pmatrix} \varphi_{1,1} & \varphi_{1,2} & \varphi_{1,3} & \varphi_{1,4} \\ \varphi_{2,1} & \varphi_{2,2} & \varphi_{2,3} & \varphi_{2,4} \\ \varphi_{3,1} & \varphi_{3,2} & \varphi_{3,3} & \varphi_{3,4} \\ \varphi_{4,1} & \varphi_{4,2} & \varphi_{4,3} & \varphi_{4,4} \end{pmatrix} \begin{pmatrix} Y_{1,t-1} \\ Y_{2,t-1} \\ Y_{3,t-1} \\ Y_{4,t-1} \end{pmatrix}$$

$$+ \begin{pmatrix} \varphi_{1,5} & \varphi_{1,6} & \varphi_{1,7} & \varphi_{1,8} \\ \varphi_{2,5} & \varphi_{2,6} & \varphi_{2,7} & \varphi_{2,8} \\ \varphi_{3,5} & \varphi_{3,6} & \varphi_{3,7} & \varphi_{3,8} \\ \varphi_{4,5} & \varphi_{4,6} & \varphi_{4,7} & \varphi_{4,8} \end{pmatrix} \begin{pmatrix} Y_{1,t-2} \\ Y_{2,t-2} \\ Y_{3,t-2} \\ Y_{4,t-2} \end{pmatrix}$$

$$+ \begin{pmatrix} u_{1,t} \\ u_{2,t} \\ u_{3,t} \\ u_{4,t} \end{pmatrix}$$

Like the VAR model we conducted for Wuhan, we plan to adopt the same research methodology for the control group Chengdu's VAR model. Based on Information Criterion AIC, HQIC, and FPE, the optimal lags of the VAR model is 2. After using the stability test to ensure that the model is stable, we establish a VAR(2) model with four variables. One of them, the lockdown, is an ordinal categorical variable, while the other three are stationary time series variables.

The above VAR (2) matrix formula can also be expressed by the following equations, where Y1 means the Total Retail Sales of Consumer Goods in Chengdu, Y2 means Consumer Price Index in Chengdu, Y3 means the Real Estate Climate Index in Chengdu, and Y4 means the Lockdown measures in Chengdu because lockdown is an ordinal categorical variable entirely determined by the government regulations, equation (11) has no economic meaning. Thus, we will omit equation (11) in the following Granger causality test and Impulse response analysis.

$$Y_{1,t} = \alpha_1 + \phi_{1,1}Y_{1,t-1} + \phi_{1,2}Y_{2,t-1} + \phi_{1,3}Y_{3,t-1} + \phi_{1,4}Y_{4,t-1} + \phi_{1,5}Y_{1,t-2} + \phi_{1,6}Y_{2,t-2} + \phi_{1,7}Y_{3,t-2} + \phi_{1,8}Y_{4,t-2} + u_{1,t} \quad (8)$$

$$Y_{2,t} = \alpha_2 + \phi_{2,1}Y_{1,t-1} + \phi_{2,2}Y_{2,t-1} + \phi_{2,3}Y_{3,t-1} + \phi_{2,4}Y_{4,t-1} + \phi_{2,5}Y_{1,t-2} + \phi_{2,6}Y_{2,t-2} + \phi_{2,7}Y_{3,t-2} + \phi_{2,8}Y_{4,t-2} + u_{2,t} \quad (9)$$

$$Y_{3,t} = \alpha_3 + \phi_{3,1}Y_{1,t-1} + \phi_{3,2}Y_{2,t-1} + \phi_{3,3}Y_{3,t-1} + \phi_{3,4}Y_{4,t-1} + \phi_{3,5}Y_{1,t-2} + \phi_{3,6}Y_{2,t-2} + \phi_{3,7}Y_{3,t-2} + \phi_{3,8}Y_{4,t-2} + u_{3,t} \quad (10)$$

$$Y_{4,t} = \alpha_4 + \phi_{4,1}Y_{1,t-1} + \phi_{4,2}Y_{2,t-1} + \phi_{4,3}Y_{3,t-1} + \phi_{4,4}Y_{4,t-1} + \phi_{4,5}Y_{1,t-2} + \phi_{4,6}Y_{2,t-2} + \phi_{4,7}Y_{3,t-2} + \phi_{4,8}Y_{4,t-2} + u_{4,t} \quad (11)$$

The above (8) - (11) are Chengdu's VAR model's equations. We can see from Table 6.9, for equation (8), the coefficient of Wuhan's total retail sales of consumer goods (both L1 and L2) are statistically significant, and also, the lockdown dummy is statistically significant. Wuhan's CPI and the real estate climate index are both statistically insignificant. Moreover, for equation (9), the real estate climate index variable (L2) coefficient is statistically significant and the lockdown dummy, meaning that the real estate condition and lockdown policy may affect Chengdu's CPI. Besides, for equation (10), the lockdown may influence the real estate condition.

		Coef.	Std. Err.	t	P>|t|	95%CI	
						LL	UL
dCDcon	Constant	0,021	0,017	1,220	0,234	-0,014	0,056
	dCDcon						
	L1	-0,872	0,166	-5,240	0,000	-1,215	-0,528
	L2	-0,026	0,165	-0,160	0,877	-0,366	0,315
	dCDCPI						
	L1	-0,017	0,027	-0,690	0,497	-0,068	0,034
	L2	-0,011	0,022	-0,480	0,634	-0,056	0,035
	dREI						
	L1	0,012	0,048	0,240	0,811	-0,087	0,110
	L2	0,052	0,045	1,160	0,258	-0,041	0,146
	Lockdown2						
	L1	-0,590	0,107	-5,500	0,000	-0,811	-0,369
	L2	0,590	0,122	4,850	0,000	0,339	0,841
dCDCPI	Constant	0,087	0,121	0,720	0,477	-0,162	0,337
	dCDcon						
	L1	-0,324	1,183	-0,270	0,787	-2,766	2,118
	L2	1,098	1,174	0,940	0,359	-1,325	3,520
	dCDCPI						
	L1	0,254	0,175	1,450	0,161	-0,108	0,616
	L2	0,128	0,157	0,810	0,423	-0,196	0,452
	dREI						
	L1	0,357	0,339	1,050	0,303	-0,343	1,058
	L2	-0,767	0,322	-2,390	0,025	-1,431	-0,103
	Lockdown2						
	L1	0,597	0,762	0,780	0,441	-0,976	2,169
	L2	-2,460	0,864	-2,850	0,009	-4,244	-0,676
dREI	Constant	0,006	0,073	0,080	0,936	-0,145	0,156
	dCDcon						
	L1	-1,629	0,715	-2,280	0,032	-3,104	-0,154
	L2	0,055	0,709	0,080	0,938	-1,408	1,518
	dCDCPI						
	L1	0,010	0,106	0,100	0,923	-0,208	0,229
	L2	-0,136	0,095	-1,440	0,163	-0,332	0,059
	dREI						
	L1	-0,053	0,205	-0,260	0,800	-0,476	0,370
	L2	0,328	0,194	1,690	0,104	-0,073	0,729
	Lockdown2						
	L1	-2,855	0,460	-6,200	0,000	-3,805	-1,905
	L2	2,758	0,522	5,280	0,000	1,680	3,836

Table 6.9: The results for the VAR (2) model in Chengdu. In the leftmost column, dCDcon represents the total retail sales of consumer goods and corresponds with equation (8). dCDCPI represents the consumer price index and corresponds with equation (9). dREI represents the real estate climate index and corresponds with equation (10). Lockdown is an exogenous variable completely determined by governmental regulations. Thus, we omit the results for

equation (11), which have no economic meaning. The above table includes the coefficients, standard errors, t-statistics, p-values, and the confidence intervals for equation (8) - (10).

6.6.3. Granger causality test - Chengdu

Like in section 6.4, we also use StataSE16 to perform Granger causality tests on the causality relationships between the total retail sales of consumer goods and the consumer price index, the lockdown variable, the national housing index, and the causality between the lockdown variable and the consumer price index. The results are shown in Table 6.10.

Equation	Excluded	F	df	df_r	Prob > F
dCDcon	dCDCPI	0,369	2	24	0,677
dCDcon	dREI	0,687	2	24	0,512
dCDcon	Lockdown2	20,549	2	24	0,000
dCDcon	ALL	11,263	6	24	0,000
dCDCPI	dCDcon	0,909	2	24	0,416
dCDCPI	dREI	3,531	2	24	0,045
dCDCPI	Lockdown2	4,056	2	24	0,030
dCDCPI	ALL	2,674	6	24	0,039
dREI	dCDcon	3,966	2	24	0,031
dREI	dCDCPI	1,038	2	24	0,370
dREI	Lockdown2	25,403	2	24	0,000
dREI	ALL	11,299	6	24	0,000

Table 6.10: Results for the Granger causality test. Under the column Equation, dCDcon represents the total retail sales of consumer goods and corresponds with equation (8). dWHCPI represents the consumer price index and corresponds with equation (9). dREI represents the real estate climate index and corresponds with equation (10). Lockdown is an exogenous variable completely determined by governmental regulations. Thus, we omit the results for equation (11), which have no economic meaning.

H0	F statistics	p-value	Result
CDCPI is not the Granger Reason for CDcon	0,3960	0,6773	Accept H0
CDcon is not the Granger Reason for CDCPI	0,9094	0,4162	Accept H0
REI is not the Granger Reason for CDcon	0,6871	0,5127	Accept H0
Lockdown is not the Granger Reason for CDcon	20,5490	0,0000	Reject H0
Lockdown is not the Granger Reason for CDCPI	4,0562	0,0304	Reject H0

Table 6.11: The null hypothesis for the causality relationships we are interested in in the study and results about whether to reject the null hypothesis or not are shown in the table based on its corresponding p-value.

As described in Wuhan's Granger causality test part, we can see from Table 6.11, p-values of the null hypothesis "Lockdown is not the Granger Reason for Chengdu's total sales of consumer goods" is rejected with the p-value equals to 0, meaning that the lockdown measures granger causes the total retail sales of consumer goods. Besides, the null hypothesis "Lockdown is not the Granger Reason for Chengdu's CPI" is also rejected by the result that the p-value equals 0.0304. What's more, according to the p-values, Chengdu's CPI and Chengdu's total retail sales of consumer goods are not Granger reasons for each other, and the corresponding p-values are 0.6773 and 0.4162.

6.6.4. Impulse response analysis - Chengdu

Figure 6.6: The graph comes from the impulse response analysis regarding Chengdu's total retail sales of consumer goods' fluctuations in 10 months after Chengdu's CPI is impacted by one unit standard deviation.

As we can see from Figure 6.6, when Chengdu's CPI is impacted by one unit standard deviation, it positively impacts Chengdu's total retail sales of consumer goods for the 1st month and then a negative impact for the 2nd month after the impact. Then the impact becomes very subtle after the 3rd month.

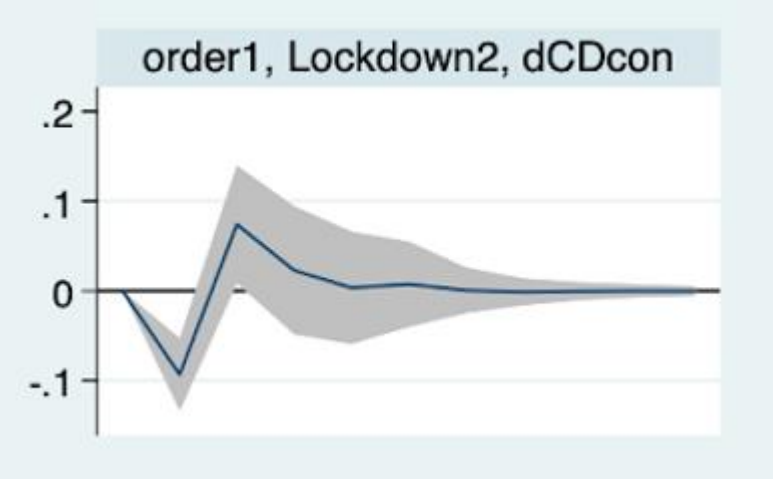


Figure 6.7: The graph comes from the impulse response analysis regarding Chengdu's total retail sales of consumer goods' fluctuations in 10 months after Chengdu's lockdown variable is impacted by one unit standard deviation.

As shown in Figure 6.7, when we impose one unit standard deviation impact on Chengdu's lockdown variable, it has a very obvious negative impact on Chengdu's total retail sales of consumer goods in the first month and then become a positive impact from the second month and reaches its maximum also in the second month after the impact, then weakens and stabilizes after then. The pattern is quite like the result of Wuhan's data.

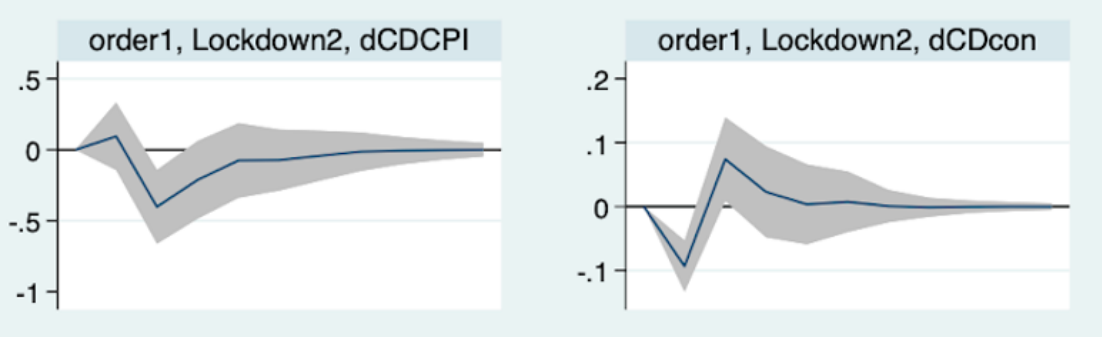


Figure 6.8: The graph comes from the impulse response analysis. The left part is about Chengdu total retail sales of consumer goods' fluctuations in 10 months after Chengdu's lockdown variable is impacted by one unit standard deviation, and the right part is regarding Chengdu consumer price index's fluctuations in 10 months after Chengdu's lockdown variable is impacted by one unit standard deviation.

According to Figure 6.8, also like what happened in Wuhan's results, when we give one unit of standard deviation impact on the Wuhan's lockdown variable, it shows an opposite impact on the Chengdu's CPI compared to the impact on Chengdu's total sales of consumer goods, which is that first the positive impact than the negative impact. Moreover, the impact almost disappears around the 3rd month.

7. Conclusion

The Covid-19 epidemic has severely impacted economic and residents' consumption. Therefore, it is meaningful to discuss the influence on consumption during a particular time. This research aimed to discuss and examine some possible channels that would be related to the decline of total retail sales of consumer goods, especially during the Covid-19 epidemic. In detail, our study focuses on the effect of consumer price index and lockdown measures on consumption from 2018 to the end of 2020 by building up a VAR model with the Granger causality test and the Impulse response analysis.

The result of our model based on Wuhan's data shows that there is no short-term relationship between Wuhan's CPI and Wuhan's retail sales of consumer goods. In contrast, the lockdown measures could affect consumption, which is represented by the total sales of consumer goods in our model. Besides, as we mentioned before, there is a possibility that independent variables may affect each other. We learned that lockdown measures could also affect Wuhan's CPI and real estate condition, which we used as a control variable in our model.

To test more about these relationships and determine if these relationships also exist in other cities in China, we used Chengdu as the control group in our research. Most of the Chengdu VAR model's results are pretty like Wuhan's result, meaning that there is no short-term relationship between Chengdu's CPI and Chengdu's retail sales of consumer goods. At the same time, the lockdown measures could affect consumption. However, Chengdu's model shows that the lockdown could not affect Chengdu's CPI but only the real estate climate index. What is more, the coefficient of lockdown in the two VAR models has a clear difference. In detail, the coefficient of Lockdown in Wuhan's model is -3.223, while in Chengdu, it is -0.590. We believe that the difference may be caused by the different strictness level of lockdown measures in these two cities. Wuhan's lockdown lasted longer and was more severe than Chengdu's.

In our hypothesis, we expect that the lockdown affects consumption with statistical significance and our empirical analysis confirmed our hypothesis in both Wuhan and Chengdu. Furthermore, we expect that the CPI should also influence the total retail

sales of consumer goods, but the empirical analysis results showed the opposite in both cities. We found the possible explanation could be that the total retail sales of consumer goods reflect more the consumption of social necessities, which means that slight rises or falls in prices will not seriously affect people's demand for necessities.

8. Reference

Binliang W. & Yanwu C. (2011) Relationship between house price fluctuation and consumption in Fujian Province. Fujian Architecture, 2011, (1).

Binkai C. (2012). Income Distribution and Chinese Residents' Consumption: Theoretical and Empirical Research Based on China. *NAIKAI ECONOMIC STUDIES*, 1, 33-49.

China Economic Situation Report Network. (2020). Corruption by country China. http://www.china-cer.com.cn/zhiku/202005185152_2.html

Central Bank. (2011). About 70% of residents believe that prices and housing prices are too high. http://jingji.cntv.cn/20110616/105972. Shtml,2011-06-16

Guangzhong, L. & Ping, C. (2002). Financial Intermediary Development and Economic Growth: Multivariate VAR system Research. *Management World, 3, 15-22.*

Hong Deng. (2011) A monistic analysis of the short-term relationship between housing prices and consumer goods prices. Monthly price, 2011, (3).

Jing R. (2020). Consumer confidence during the COVID-19 pandemic. *Hot Square, 11-12.*

Jing Y. & Shixiang Z. (2020). The impact of COVID-19 on my country's economy. *Times Finance, 35-38.*

Jian C. & Bo G. (2012) Income Gap, Housing Prices and Consumption Changes——Analysis Based on Panel Data Simultaneous Equation Model. Shanghai Economic Research, 20120, (2)

Jianghui Z. & Yifu F. & Jin T. (2020). Analysis of the impact of the COVID-19 epidemic on the consumer economy and countermeasures. *Consumer Economics, 36(2), 3-9.*

Juncong, G. (2020). Research on the Importance of Consumption for Stable Growth. *SHANGYE JINGJI, 2,* 126-131.

Khaled, H. (1996). Financial Development and Economic Growth: Cointegration and Causality Tests for 16 Countries. *Journal of Development Economics, 5,* 387-411.

Lingling L. (2018). An Empirical Analysis of Keynes' Absolute Income Theory Model-Take Henan Province as an Example. *Financial management,* 4, 41-44.

Liuying L. & Jiateng W. (2020). Analysis of the impact of the COVID-19 epidemic on residents' consumption behavior and its formation mechanism. *Consumer Economics, 36(3), 19-26.*

Munich Personal RePEc Archive. (2018). Corruption by country Australia. https://mpra.ub.uni-muenchen.de/84383/

"Resident Consumption" Research Group, Institute of Financial Big Data, Chinese Academy of Fiscal Sciences. (2020). The impact of the COVID-19 epidemic on residents' consumption. *China Finance News, 007, 1-3.*

Rong, Z. & Caiqin Z. (2015). House price index, CPI, and social consumption level - an explanation based on impulse response and variance decomposition. *ACADEMIC FORUM, 10,* 71-74.

Se Yan. & Zhongguo Z. (2013) "House slave effect" or "wealth effect"? ——A theoretical analysis of the impact of rising housing prices on national consumption. Management world. 2013, (3).

Shiguo Miu. (2011). Price Stability and Housing Price: A Monetary Policy Perspective. Contemporary economic sciences. 2011, (4).

Toda, Y. & Taku, Y. (1995). Statistical Inference in Vector Autoregressions with Possibly Integrated Process. *Journal of Econometrics, 66*, 225-250.

Xiao, C. & Jun, W. (2002). Granger Test and Characteristic Analysis of the Relationship between China's Financial Development and Economic Growth. *Finance and Trade Economy, 5*, 7-13.

Yang Y. & Guiyuan Y. (2020). Analysis of the impact of the COVID-19 epidemic on my country's consumer demand. Corruption by country China. http://www.fx361.com/page/2020/1109/7195085.shtml

Yuqing Z. & Yingheng Z. & Zhongyi Y. (2014) An Empirical Analysis of the Fluctuation Spillover of Economic Early Warning Index, National Housing Climate Index and CPI Index——Based on the ternary VAR-GARCH-BEKK model. Statistics and Information Forum, 2014, (3).

Zhiqiang, W. & Gang, S. (2003). Empirical analysis of the relationship between China's financial development scale, structure, efficiency, and economic growth. *Management World, 7*, 13-20.

Zuoyan L. & Chaohui L. (2005). An Empirical Analysis of the Changes in Chinese Residents' Consumption Trend and Its Influencing Factors. *Consumption Economy*, 21, 14-17.

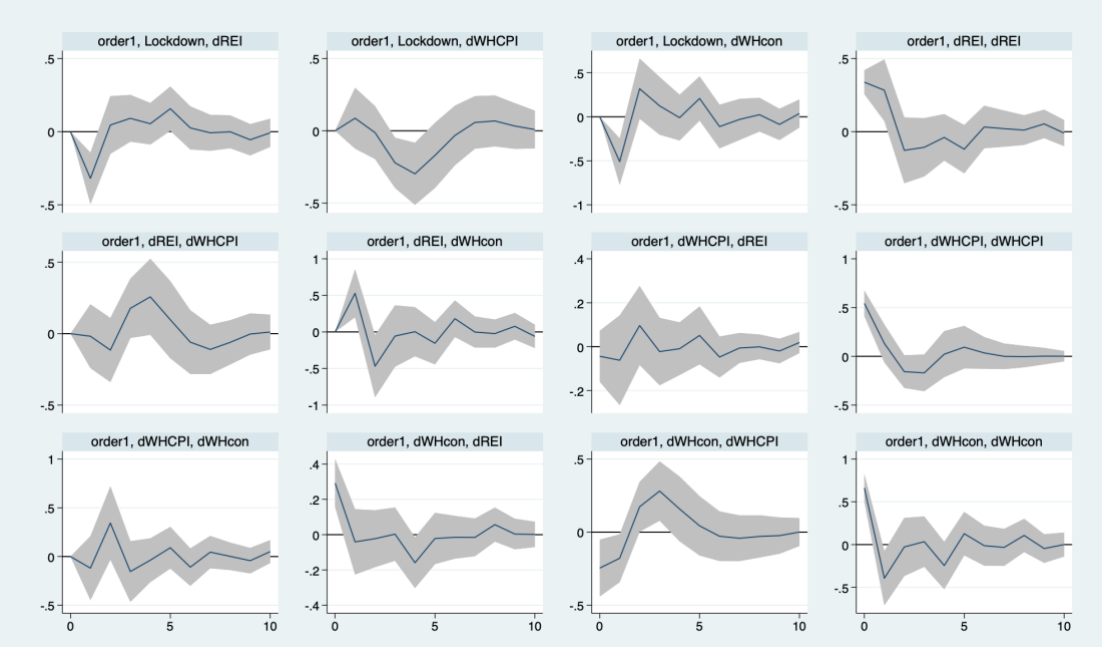
Zhihua F. & Zhigang W. (2020). The impact of new crown pneumonia on residents' consumption and countermeasures. *Financial Science*, 4, 33-40.

Zhuoran S. & Hui L. & Man Y. & Yaping H. (2020). Empirical study on the effect of offline shopping and entertainment travel restrictions in Wuhan during the epidemic. *National Nature of Science Foundation of China.* http://jtp.global.cnki.net/bilingual/detail/html/JJDL202004011

9. Appendix

Appendix 1 – Impulse Response Analysis in Wuhan

The impulse response results based on Wuhan's VAR model, where we give impulse to the Wuhan's consumption, Wuhan's CPI, real estate index and the lockdown variable and show the response from Wuhan's consumption, Wuhan's CPI and real estate index.



Appendix 2 – Impulse Response Analysis in Chengdu

The impulse response results based on Chengdu's VAR model, where we give impulse to the Chengdu's consumption, Chengdu's CPI, real estate index and the lockdown variable and show the response from Chengdu's consumption, Chengdu's CPI and real estate index.