The Chinese Residential Housing Market during COVID-19: A Panel Data Analysis

Bachelor Thesis

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1 Introduction

1.1 Background

People detected the COVID-19 virus for the first time in Wuhan, China, in the December of 2019. Over the past three years, the virus has spread to every country globally (Reuters, 2022). Like all the other governments worldwide, China has taken strict measures against the virus and its variants since the beginning. Epidemic prevention measures help control the virus's rapid spread and buy time for human beings to develop and inject vaccines. However, the responses, including hard lockdown and imposing restrictions on businesses and social activities, have significantly impacted all economies in a negative direction. According to McKibbin and Fernando (2020), The pandemic has significant negative consequences on most industries in this world. The impact shows up in many aspects, such as decreasing in consumer spending (Chetty et al., 2020), increasing in the global unemployment rate (Beland et al., 2020; Borjas & Cassidy, 2020; Dingel & Neiman, 2020) and increasing volatility in the investment return rate of equities (Milcheva, 2021). Until April 2022, China is still taking hard lockdown as a way to control the virus and keep a zero-tolerance strategy, which is officially called Dynamic Clearing. Even though in the Meanwhile, some other leading economies, such as the United States and European Union, have declared that they will coexist with the virus and started to adjust macro policy to accelerate the progress of the recovery of economies.

Even though the overall impact of the epidemic on every economy in the world has been proven to be significantly negative, but when it comes to the industry level, the direction of impact is still ambiguous. The tertiary industry led by tourism is the most affected by the epidemic. As the virus sweeps across the world, most governments introduce shutdowns and travel restrictions to control the spread of the virus. A series of studies have investigated the effects of the potential negative impact of pandemics on tourism (Aliperti et al., 2019; Cró & Martins, 2017; Kuo, Chen, Tseng, Ju, & Huang, 2008; Sio-Chong & So, 2020; Song, Livat, & Ye, 2019; Wang, 2009). In China, compared to 2019, international visitor arrivals even fell by more than 99% in 2020. The manufacturing industry also suffers from the decline caused by the pandemic. Due to the production disruption of raw materials and spare parts, the decline in market demand, rising financial risk, and lack of labour, a large amount of small and medium-sized enterprises in this industry went bankrupt (Cai & Luo, 2020).

However, economists also noticed that explosive growth occurs in certain industries that are related to the changes caused by the epidemic. For instance, the surge in global demand for medical devices and antiviral drugs to fight the coronavirus has also brought about a short-lived boom in the two industries. (Barshikar, 2020). Shutdowns of education institutions also raise the demand for online learning platforms like Coursera and Zoom. (The World Bank, 2020). Similar prosperity also occurs in the Internet industry. Demand for broadband communication services has soared since the onset of the COVID-19 crisis, with some operators seeing 60% more internet traffic than before the crisis (OECD, 2020).

During the pandemic, the Chinese housing industry, which accounts for more than one-third of GDP in the second-largest economy on Earth, is also facing variations. Gorddard and Ajami (2022) reckon that the crisis of Evergrande in 2020 is a symbolic event that represents the beginning of the decline of the whole industry. The public media, led by The Wall Street Journal, also showed a negative insight into the Chinese housing market, especially the residential housing market (The Wall Street Journal, 2022). Even though, as stated by Liu (2018), the decline of the Chinese residential housing market is partly because of the change in financing policies. However, we should not ignore that previous pandemics such as SARS in 2003 can negatively affect the Chinese real estate market (Wong, 2008).In this research, we would like to look into whether the COVID-19 pandemic partially caused the shrink of the Chinese housing market since 2020.

1.2 Central Question

We will focus on the direct and indirect impact of COVID-19 on the Chinese residential housing market scale by constructing a model that reflects how the factors reflect the status of the pandemic affects sales in different regions. According to Ren(2021), after 2018 Chinese residential housing market has already been in a supply and demand imbalance. Zhao et al.(2017) also claim a similar conclusion. In that case, using traditional supply and demand analysis in our research is not reasonable. We will go through previous research on the development of Chinese real estate and summarise potential factors that may play roles in our topic. The central question of this article is:

How does COVID-19 impact the Chinese residential housing market demand?

To approach a powerful answer to our central question and test our hypotheses. We will construct our article below into several parts. Firstly, we will move on to review current existing literature that analyses the impact of major disasters or social events on the real estate market. After that, we would like to focus on our data and construct a model to explain the direct and indirect impacts. We will end

up with our predictions for the future change in the market and present our suggestions for policy-making.

1.3 Relevance of the research question

Real estate plays an essential role not only in the economy of China but also in all countries with a capitalist market economy. By studying the impact of the COVID-19 pandemic on the size of the residential housing market, people can evaluate the damage and take corresponding measures to recover the economy. Moreover, in the thousands of years of human history, there have been many battles against plagues, such as the Black Death in Europe in the Middle Ages, the Spanish flu in World War I, the SARS virus at the beginning of this century, and the H1N1 virus a few years ago. As European Commission claims, future pandemics are inevitable, but human beings can work together to reduce the risk (Smith, 2021). Although the destructiveness of COVID-19 to the global economy is extremely high compared to most previous pandemics. But this outbreak has given us invaluable experience in combating potentially more severe outbreaks in the future. We would like to provide a perspective to study the impact on the real estate industry and summarise what we might be able to do during the next pandemic to protect this essential industry.

2 Literature Review

2.1 Impact of disasters on the real estate industry

In this part, we would like to review existing research that inspires our research. We would like to look into how the previous disaster affected Chinese residential housing. We select the SARS pandemic in 2003 as our main focus and will also review the market responses to other natural disasters. We would also like to investigate how COVID-19 affects housing markets in other countries. Then we will summarise what kinds of gaps our research will fill in this topic.

The last serious pandemic that caused the Chinese government to take similar prevention measures was SARS in 2003. Many economists believe that the SARS pandemic had no devastating effect on the real sector in Greater China. Wong (2006) detects that the amount of SARS infections in an estate significantly negatively affect housing prices in Hong Kong. But no overreactions were detected in the market during the pandemic, and the prices also returned to their original level after months. Short-term negative market responses are also detected by Chou et al. (2004) in Taiwan. The GDP in the real estate sector in Taiwan dropped 7.7 per cent, and the authors assert that it is mainly because of

the negative impact of the pandemic on the customers' sentiment. But the market size soon came back to the norm after months. Cheung et al. (2006) also assert that the SARS outbreak did not change customers' behaviours in the property market. The preferences and the desire to buy properties remain stable after a short vibration. Opposite the findings above, Zhang et al. (2021) claim that the SARS pandemic actually positively affected the Chinese real estate sectors. In their opinion, the financial market is more sensitive to the fluctuations in the market, and when the pandemic began, more capital flew into the real sector, which was relatively less risky.

However, the economic status and severity of the two pandemics are completely different. For instance, the SARS outbreak lasted only less than two years, from the first case detected in China to the World Health Organization declaring the virus contained. But since the first case of COVID-19 was detected, three years have passed, and there is no clue when this pandemic will come to an end. Moreover, according to the research on the spatial pattern of SARS conducted by Xu et al.(2014), only three provinces had more than 453 cases, and the spread of the virus was very limited, the cases were usually concentrated in several neighbourhoods. Compared to COVID-19, SARS has a limited impact on economic activities. Moreover, the market size of the Chinese real sector has increased dramatically. According to the report issued by the National Bureau of Economic Research (2020), it is estimated that China's real estate sector accounts for 29% of China's GDP and is about 4 trillion dollars. But in 2003, the overall GDP in China was only 1.66 trillion dollars (Country Economy, 2004). In that case, we highly doubt that the results are still applicable to the COVID-19 pandemic.

Although, we did not find evidence to show that the previous pandemic had a significant negative impact on the real estate market. However, Extensive literature proves that natural disasters have a persistent negative impact on China's real estate market in affected areas. A typical example is the housing market in Sichuan province after the Great Sichuan earthquake in 2008. After the extremely tragic disaster that took away hundreds of thousands of lives in Sichuan, Chengdu, the province's capital city, was deeply affected in terms of economics. For the real estate sector, Deng et al. (2015) examine that the occurrence of the earthquake caused a significant change in customers' preferences in the housing market. For instance, the prices on lower floors considerably increased in several years onwards. The authors think natural disasters can significantly change people's risk perception and directly reflect on the markets. Natural disasters' impacts do not occur on the demand side but also on the supply side. Marketing is one of the core parts of the real estate business. During the following months after the earthquake, many developers must adjust their marketing strategies to deal with the increased risk perceptions of earthquake risk (Yin et al., 2019). The earthquake also significantly slow down the local urbanisation process and led to a decline in the regional real estate market (Abramson & Qi, 2011).

Similar negative effects are also detected in housing markets during this COVID-19 pandemic. Liu& Su (2021) investigate the impact of the COVID-19 pandemic on the housing market in the U.S. The authors claim that the main impact comes from the pandemic's reduced housing demand in dense neighbourhoods, as people seek safer places to keep a farther distance from others. But unlike the two disasters we mention above, the impact of COVID-19 on real estate markets mainly occurs on the supply side. Because of the stay-at-home policies applied in most countries in the world, developers face stoppage forced by the governments, which increases the risk in the real estate chain (Uchehara et al. 2020). The outbreak also causes a significant increase in operating costs and a decrease in net income and investment value for the developers. The developers have to adjust their business plans and marketing strategies to survive. Most importantly, there is no clue when the effect will come to an end, and the market will face uncertainty for a long time (Tanrivermis, 2020).

2.2 Fundamental Factors in the Chinese Housing Market

Two models collectively form the framework's basis for analysing our central question. The first one the established by Wang and Zhang in their work "Fundamental factors in the housing markets of China" (Zhang & Wang, 2014). They summarise the primary factors that impact the size of the Chinese residential housing market. West and Lenze introduce the second model in their work, "Modeling the Regional Impact of Natural Disaster and Recovery: A General Framework and an Application to Hurricane Andrew" (West & Lenze, 1994). They provide a model to analyse the economic impact of natural disasters. This section will introduce the first qualitative model and explain its applicability in our study. We will introduce the second quantitative model in a later part.

Before introducing our first framework. In order to better understand the impact of COVID-19 on the industry and our discussion in the later part. We would like to briefly introduce the Chinese real estate industry's development.

First of all, we need to introduce the unique system called *hukou*, which is left over from the era of China’s planned economy to control population movement in China. The system results in the difference in real estate industries between China and any other country. It helps explain the urbanisation process in China and why real estate industries boom in all provinces in China.

According to the Regulations of the People's Republic of China on Residence Registration, hukou refers to the legal documents issued by the national household registration management agency to record and preserve basic household registration information. Items recorded include the natural

person's name, date of birth, relatives and marital status. It is the basic legal document to determine the legal status of a natural person as a civil subject (People's Government of China, 1958).

Hukou restrict the provincial movement of Chinese citizens for decades of years, but the system also reserves labour for economically backward regions. Housing is a rigid demand for human beings. When there is a large number of labourers in each area, the demand side of the housing market will rise accordingly (Cheng & Selden, 1994). Recently the Chinese government has just announced that it will gradually abolish the hukou restrictions in the foreseeable future and only keep it in a few large cities like Beijing, the capital city (CGTN, 2020). Since hukou restricts population mobility and the Chinese government has rigid requirements for local urbanisation rates, all provinces across the country have seen many intra-provincial rural populations move into cities in recent decades. This phenomenon has led to a sharp rise in the rigid demand for residential housing. In addition to the increase in rigid demand, with the rapid development of China's economy in recent years, the demand for improved housing has also significantly increased.

Furthermore, China established its real estate market much later than the Western countries. The market is still highly affected by public and financial policies, but it is also growing rapidly. Table 1 includes all the major real estate events obtained by reviewing the People's Daily of the corresponding time.

Table 1: *Development history of China's real estate industry.*

1978-1998	China began to carry out market-oriented reforms, and China's real estate industry formed and began to take shape.
1998-2003	Affected by the Southeast Asian financial crisis, the Chinese economy experienced a hard landing, and the economic growth rate declined for eight consecutive quarters. In order to curb the danger of further economic downturn, the central government is determined to cultivate new economic growth points. The real estate market has entered the vision of policymakers, and the policy side has begun to change.
2003-2013	In the 10-year development cycle, China has gradually formed three major economic "carriages" of consumption, investment and export trade. Among them, investment and exports constitute the core of China's growth, and real estate is an important force for investment. Since 2010, the proportion of the real estate economy to GDP has exceeded 25%.
2013-2019	At the end of 2012, the new Chinese government established the development concept of "urbanization". China is trying to change the previous real estate development model centred on "land" to one centred on "people". The house price per square meter in some parts of China has reached the level of the average two-year salary per capita, such as Shenzhen. The Chinese government proposes the concept of "housing is not for speculation". In 2019, real estate developers began to experience frequent bond defaults and wage arrears. This phenomenon is often attributed to high leverage and short cycles.

Source: People's Daily (1978 - 2019)

From the introduction above, we can see several characteristics of the Chinese residential housing market:

Firstly, since the state is the sole landowner in China, the development of the market is highly affected by the policy. Every major event in the real estate industry in history is closely related to national policies. The government has also been guiding the real estate industry to develop in a direction that is relatively in line with national interests.

Secondly, Although the birth and development of China's real estate industry are inseparable from policies. But we can see that market factors gradually dominate after 2013. Therefore, when

conducting research on the real estate industry, we should increase the proportion of market factor analysis to make our research more advanced with the times.

Thirdly, China's real estate industry already has a huge bubble. Referring to the bursting of the Japanese real estate bubble in the 1990s, the Korean financial crisis in 1998, and the subprime mortgage crisis in the United States in 2008, when the local real estate bubble was huge, the structural market risk increased greatly. collision. And the huge impact of the epidemic makes us have to consider whether the impact has burst the bubble.

After the overview of the whole industry, we would like to move on to focus on the first framework we will use, namely, Wang and Zhang's framework for analysing the fundamental factors in the housing market of China (Wang & Zhang, 2014). Wang and Zhang (2014) analyse the housing market from two perspectives, the residential development level and the city level. We will make use of the city-level framework in our research, as in the later part, the readers will see that we collect provincial data to study, which is close to the level of the framework. The authors claim that changes in fundamental factors such as urban hukou population, wage income, land supply, and construction costs can account for a large proportion of actual variations in the activity level and size of the residential housing markets. It is very important to control for the above variables in our study.

2.3 Research Gap

We find that even though most researchers agree that the lockdown policies taken by the governments directly cause the decline in the real estate industry. However, hardly any people conduct research to quantify the impact and estimate the exact magnitude of the effect in China. We would like to model the impact of the pandemic on the residential housing market and try to introduce a variable that accounts for the lockdowns. However, statistical data for lockdowns have never been collected by any researchers. Lockdown measures are usually at the discretion of district and county governments. To achieve this goal, we manually collect data regarding lockdowns and solve the data collection problem.

Moreover, compared to the beginning of the pandemic, the virus and countries' measures against the outbreak have changed. For instance, the Chinese government has decreased the quarantine period for infected patients from 70 to 14 days, and the major prevalent virus has changed from the original to more infectious Omicron vibrant. In that case, the conclusions and models in previous studies on this topic may not be valid as before. An impact evaluation model based on all epidemic data from 2020 to 2022 is still missing in current economic research. Our research will also provide an up-to-date complement analysis of this topic to fill the gap.

3 Method

3.1 Modelling the Regional Impact of Natural Disaster on the Economy

A traditional framework that will contribute to our research is a model for analyzing the economic impact of natural disasters, established by West and Lenze in 1994. West and Lenze (1994) point out that when researchers study the impact of natural disasters, the problem required is far more than changing exogenous variables or changing the current state of dynamically endogenous variables. Researchers should also account for the fundamental models. Because there may be some indirect influence in natural disasters, the error of the original model becomes larger. Back to our research, it means that we should analyze whether the traditional real estate fundamental factor analysis model still has validity during the COVID-19 pandemic. In order to keep the validity, we should account for the indirect impact and potential mechanisms generated by the disasters.

Furthermore, West and Lenze (1994) argue that efforts to measure direct effects can magnify the lack of underlying data. Detailed and precise raw data are needed to reduce uncertainty in our results. The authors also suggest that researchers develop a systematic empirical framework combining primary and secondary data to generate the detailed economic inputs needed to analyze the regional impacts of natural disasters.

The framework's final point is to a determination of both direct and total impacts during evaluation. Using fairly simple and non-rigorous impact evaluation may lead to a reasonable result, but the results are not actually realistic.

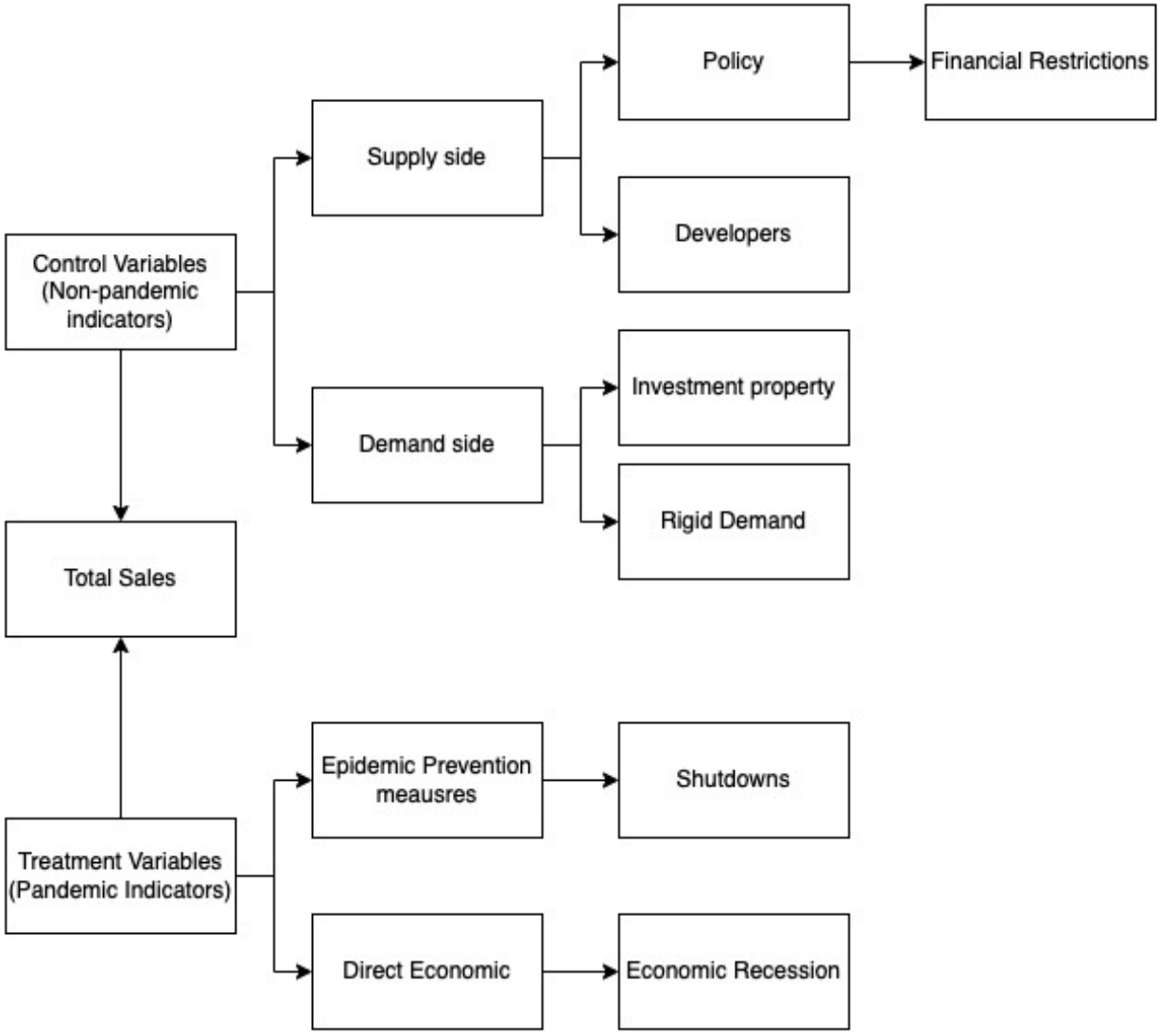
3.2 Application of the frameworks in our research

We will make use of the Wang & Zhang (2014) framework for analyzing the regional residential housing market to construct the fundamental models of the market size. The fundamental model will show the ex-ante status of the Chinese residential market. We will build a quantitative model that can reflect the supply and demand sides through different variables. By controlling these variables, I could have separated the impact of the epidemic from the total change as much as possible. As mentioned before, variations in policy and production behaviours of developers are the two main drivers in the change of supply sides. The demand sides can be categorized into two types, demand for investment

property and rigid demand. For the impact of the COVID-19 pandemic, we will analyze the direct and indirect impacts separately. According to the previous literature, epidemic control measures are the main source of indirect impact.

We establish the following figure to help our readers understand how the models will be built. Figure 2 shows the framework.

Figure 2: *Framework for studying the impacts of the pandemic on residential housing sales.*



3.3 Province Fixed Effect

Province fixed effect is a quantitative method for evaluating the impact of certain treatments on the provincial level. It is particularly useful for analysing panel data which is exactly the type we have in this research. The method takes the individual objects as its counterfactual. By comparing the same province with and without treatment, we are able to cancel out the effect of time-invariant variables that may affect our results.

To support our choice of fixed effect model rather than random effect model, we conduct Hausman Test. Table 3 show the results of the diagnostic test.

Table 3： *Results for Hausman Test*

	Random Effect	Fixed Effect	Difference	Standard Error (Type I)
Lockdown	-90.2037	-91.3915	1.1878	0.6849
Infections	-18.4618	-18.4670	0.0052	0.2731
PMI	35.1163	35.1047	0.01155	0.7437
PE	0.3501	0.3505	-0.0004	0.0104
Unemployment	80.5892	80.5287	0.0605	1.9809

Note: All the data are collected from the National Bureau of Statistics. Chi-square is 3.01, P-value is 0.6984. This test's null hypothesis is that the coefficient difference is not systematic.

According to table 3, we obtain a P-value of 0.6984 in the Hausman Test. Compared to our significance level of 0.05, the P-value is much higher. In that case, we can conclude that the coefficients of the random effects model are far away from the fixed effects model we have. Based on the less restrictive assumptions that fixed models have, the model we construct are more likely to be closer to real situations. Hence, in our topic, the fixed effect model is more robust than the random effect model.

We would like to investigate the impact of the pandemic on the residential housing market in terms of sales from two perspectives, namely, the impact of the prevention measures and the direct impact.

Firstly, we would like to construct the model describing the relationship between Sales and daily infections to show the direct impact, which means we will omit the lockdown variable. Then, we would like to remove the variable of daily infections to study the isolated impact of lockdowns to investigate in effect caused by the prevention measures, which means we will omit daily infections here. Finally, we will combine the two models to show an overview of the impact. The general form of our regression model is as below:

$$Sales_{it} = \beta_0 + \beta_1 dailyInfections_{it} + \beta_2 Lockdown_{it} + \beta_3 PE_{it} + \beta_4 PMI_{it}$$

$$+ \beta_5 CloseContact_{it} + \beta_6 Unemployment_{it} + \varepsilon_{it}$$

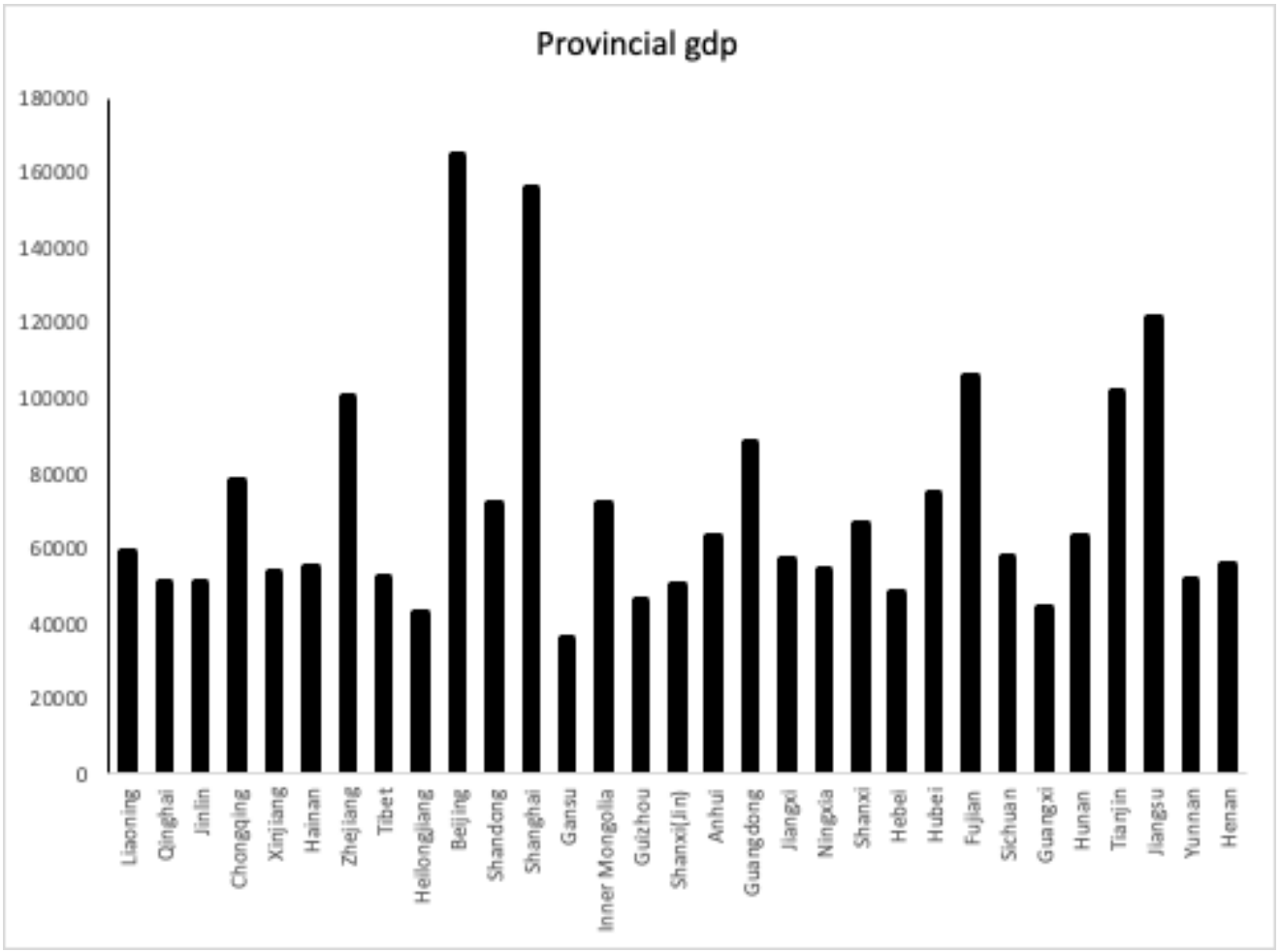
where i = provinces, t = time, ε_{it} is the error term

We should ignore the importance of matching our data points in no account, especially for the daily infections data. The data of infections are often announced one day later. When it comes to the policy response to the increasing number of daily infections, it usually takes a longer time. Furthermore, the virus itself has an incubation period of 0 to 14 days, and the latest variant, Omicron, has an even longer incubation period. To solve this problem, we replicate the models with different lags, and we finally find that infection data lag 5 periods has the lowest P-value, which is 0.000, which means daily infections with a lag of 5 months is the most significant coefficient.

3.4 Hypotheses

With the purpose of answering our central research question, we will break the market down geographically and study the effect separately, and we would like to end up with an entire perspective on the situation of the market. In that case, we will firstly keep our eyes on the provincial variation in the housing market. According to Zhang et al. (2020), Chinese housing markets highly depend on provincial regulations and policy changes. It is partially because significant inequality still exists between the different Chinese provinces regarding the economic situation. For instance, in 2020, the GDP per capita of the richest province, Jiangsu, was four times higher than the poorest province, Gansu. Readers can see the detailed data in figure 4.

Figure 4: *GDP of provinces in China (CNY), 2022.*



Source: the National Bureau of Statistics.

Moreover, the situation of the pandemic also differs across the provinces. According to the National Statistical Office, Shanghai has more than 500 thousand new cases of infections in 2021; meanwhile, Tibet remains 0 cases since early 2021. As such, our first hypothesis echoing this thought is

H1: The pandemic has various impacts on different provinces.

Even if the development level of the economy, characteristics of populations, policies and strategies regarding real estate industries differ provincially, Beijing has adopted a nationwide epidemic prevention measure amid the COVID-19 pandemic. We read through Diagnosis and Treatment Protocol for COVID-19 issued by Politburo, version 1 to version 8, and find that Beijing adopted nationwide response prevention measures from 2020 to early 2022. When an infected case of asymptomatic infection occurs in a province, all provinces that the patient passes through have to shut

down. Due to the wide spread of the virus, almost all provinces have experienced lockdowns in every stage of outbreaks. Such a strict measure is based on the fact that inter-provincial mobility in China is high. In that case, it is reasonable to consider the pandemic's overall impact on the residential housing market. We would like to take the number of infections as representative of the stages of outbreaks. Then our second hypothesis is

H2: The increasing number of infections has a negative effect on the Chinese residential housing market as a whole.

Besides infections, we should also not ignore another potential shock in the market, which is the government's response to the new confirmed cases. After the outbreak, many countries take a measure of hard lockdown to control the spread of the virus. Specifically, it means the movement of citizens between cities or neighbourhoods, operation of business and production, and other activities will all be forbidden during the policy is imposed. Even though hardly any countries are still using such a policy, China has been using it since the beginning of the pandemic. The Chinese government shut down Wuhan first in February 2020, and several cities are still under hard lockdown, including the capital city of China, Beijing. Such a policy did control the pandemic relatively efficiently, but the lockdown also imposed a significantly hard burden on the economy. For instance, Jilin province, a northeastern province that relies on the automobile industry, is experiencing a decline in the whole economy because of its lockdown in early 2022. Jilin Province still maintained a GDP growth rate of 6.6% in 2021, but in the first quarter of 2022, the province's GDP fell by 7.9% year on year (Statistic Bureau of Jilin, 2022). There is a significant decline in the growth rate of Jilin in terms of GDP between before and after the lockdown. We proposed that such a negative impact may also exist in the real estate industry. Our third hypothesis is

H3: The hard lockdown policy negatively affects the residential housing industry in China.

In 2021, the Chinese declared that regulators should strive to eliminate speculation in the housing market (Fortune, 2021). However, in other words, for a long time, residential houses have been regarded as an investment product with relatively less risk and a higher return ratio (Coulson & Tang, 2013), as reported by Lau (2021). Unlike in some western countries, people are more likely to invest their money in financial derivatives or insurance. By 2021, more than 70% of the Chinese households' wealth stores in residential housing, while only around 35% in the US. In China, households, companies and even the governments highly rely on investment in real estate. For example, in the capital city of Henan province, Zhengzhou, more than 40% of the government's revenue comes from the sale of land, according to the Statistic Burea of Henan (2018). Moreover, even though Chinese citizens are more tend to save their income in banks, people still have a rigid demand for investment.

In this incident, if we assume that the total demand for investment remains, then we can reasonably propose that investors in the Chinese real estate market may seek other investment opportunities when the residential housing market is negatively affected by the pandemic and vice versa. To test it, we have our fourth hypothesis:

H4: The pandemic has different effects on the real estate market and the other financial market.

We will try to support the four hypotheses above in the following research in order to obtain a reasonable answer to our central question.

4 Data

We take panel data as our data structure in this research. Panel data shows the behaviour of entities is observed across time. In our research, the entities are the 31 provinces in mainland China. Panel data allows us to control for variables we cannot observe or measure, for instance, the regional shadow economies or private housing transfers. In other words, we are able to account for individual heterogeneity.

Compared to cross-sectional data or pure time-series data, panel data is relatively more efficient in modelling groups' common and individual deviations. Panel data can also minimize estimation biases. Typically, panel data includes a certain number of observations *(n)* on multiple individuals (ranging from $i = 1,...,k$).

Due to the completeness of the data source, after simple data clearing, the final dataset we use is strongly balanced. The dataset we use consists of data from 31 provinces over a period of 28 months, from the outbreak of the pandemic in April 2020 to April 2022. We only include all 31 provinces on China's mainland. In other words, we exclude Hong Kong, Macau, and the disputed area, Taiwan. The other reason we exclude the three areas is for the sake of decreasing the effect of heterogeneity, as all the three areas made their own policies when facing this new virus, and the business logic of the real estate industry there is significantly different as well. Problems such as measurement error can be ignored in this research because a unified national standard is adopted for statistics across all 31 provinces.

All the data on infections, close contact, and PMI are obtained from the Chinese National Bureau of Statistics. We count variable lockdown manually through the daily news report of China Central

Television. As for real estate data, we would like to obtain it from Wind, the largest Chinese business database with abundant data on real estate industries. Other data regarding economies can be downloaded from the governments' monthly statistical reports.

4.1 Variables Definition and Sample selection

A total of 868 monthly data regarding the provincial residential housing market and the COVID-19 pandemic are pooled from 31 provincial databases and the national statistical office. We will introduce all the variables we use in this part.

4.1.1 Identification variables

We are going to analyze a series of panel data that showed historical data regarding the pandemic and economies in terms of provinces. The following variables will be included in this research:

province: Provinces are categorical variables that have 31 categories representing 31 different provinces in China, mainland. We exclude Taiwan, Hong Kong and Macau from this research because of China's "One country, Two systems" policy. All three regions have a high degree of autonomy. Therefore, they all have independent and completely different real estate systems, population management systems, and even currency and economic systems from mainland China. Similarly, in this epidemic, the three regions also have independent power to formulate epidemic prevention and control measures. Therefore including these three regions would greatly reduce the internal validity of our model In this research, we take each province as an independent market.

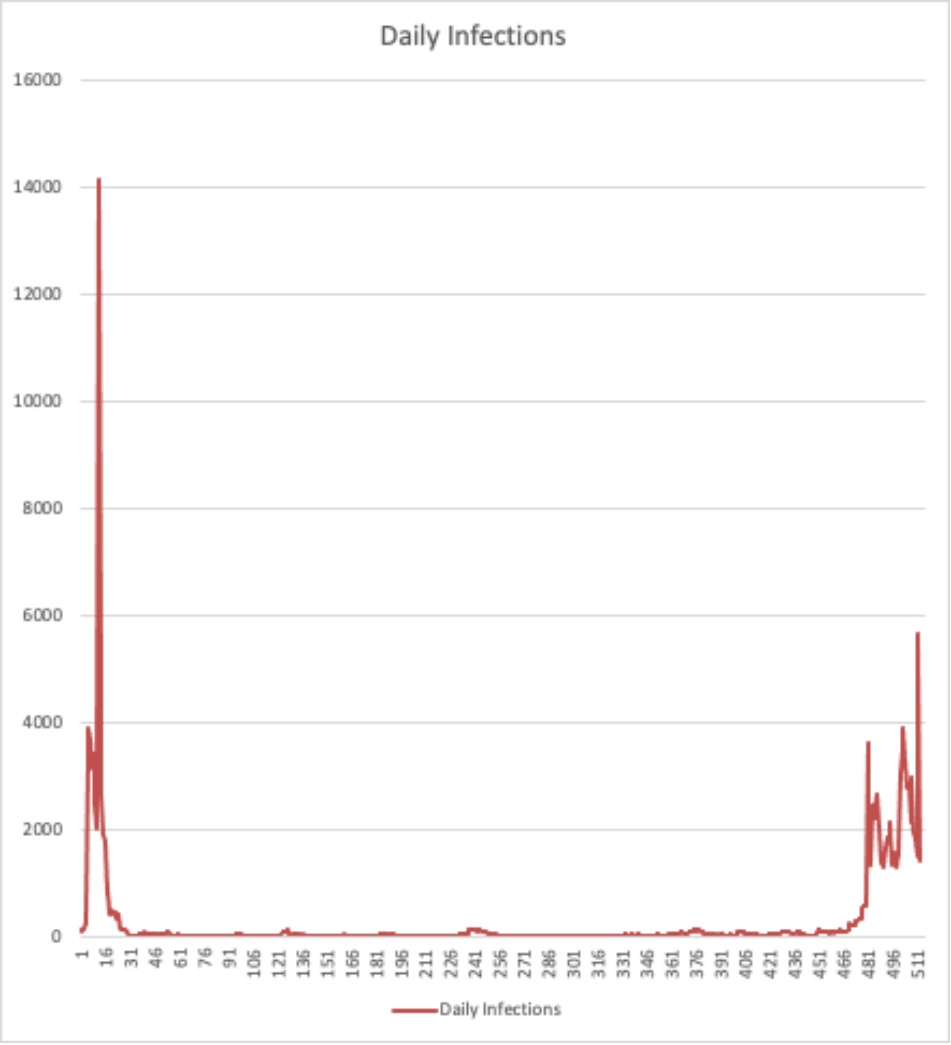
time: time is a time variable that has a value ranging from 1 to 28. For instance, if t = 5, it means the whole row of variables refers to the value of the 5th month from the beginning of the pandemic, which is September of 2020.

4.1.2 Pandemic indicators

Infections: Daily infections show the daily amount of infections of COVID-19 (including the original virus and all the other variants). Figure 6 plot the records of daily infections over the periods of the time variables. We can see an obvious U-shape in the figure. In the beginning, roughly from time = 1 to time = 31, the government lacks experience in dealing with the new virus outbreak, so there is a peak of infections during this period. After t = 421, which is late 2021, the Omicron variant of COVID-19, known for its high infectivity and low pathogenicity, is detected in China. The variant spread all over China rapidly and directly caused lockdowns in several big cities in China, including

Shanghai and Beijing. The overview of this variable is as below. To facilitate our research, we combine daily infection data and generate monthly infection data. The data is obtained from the National Bureau of Statistics. Figure 5 shows a line graph of the daily infections.

Figure 5: *Daily infections during the COVID-19 pandemic in China.*

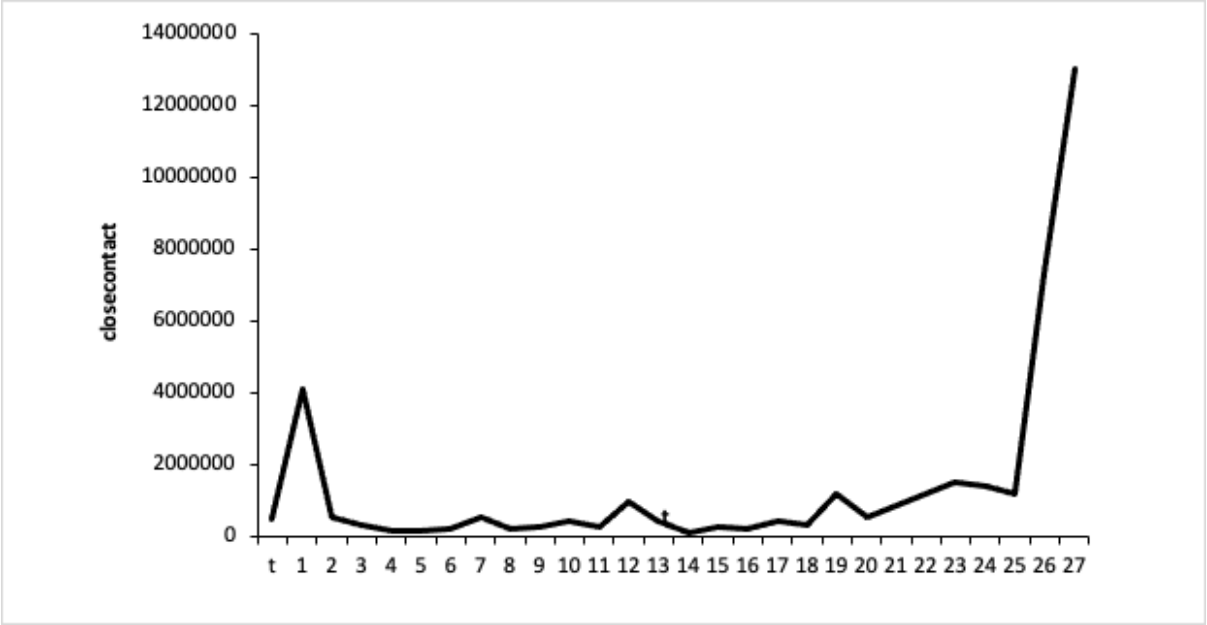


Source:the National Bureau of Statistics.

lockdown: It is a dummy variable that shows whether the province applied a hard lockdown policy within the month in its main cities. The hard lockdown includes shutting down all businesses in the area, quarantining infections and close contacts, doing tests for everyone in the area twice a day and other restriction measures. The value 0 means that the province did not apply a hard lockdown policy, and value 1 means the province locked down its main cities in that month(capital cities or main industrial cities). We collected this data by reading through the daily official announcements published on China Central Television's website from January 2020 to April 2022.

close-contact: According to the definition provided by Shanghai Municipal Health Commission, close contacts refer to those who had close contact but did not take effective protective measures or had contact with potentially contaminated environments four days before the onset of symptoms in suspected and confirmed cases, or four days before asymptomatic samples were taken, Infected staff etc. Close contacts usually face the prospect of removal to quarantine and the area immediately around where they live being locked down again. Sub-intimate ties refer to people who are in frequent contact with the above-mentioned close ties, such as living together, working together, and studying together. The data is obtained from the National Bureau of Statistics. Figure 6 shows a line graph of the close contacts.

Figure 6: Monthly data of *close contacts during the COVID-19 pandemic in China.*



Source: the National Bureau of Statistics.

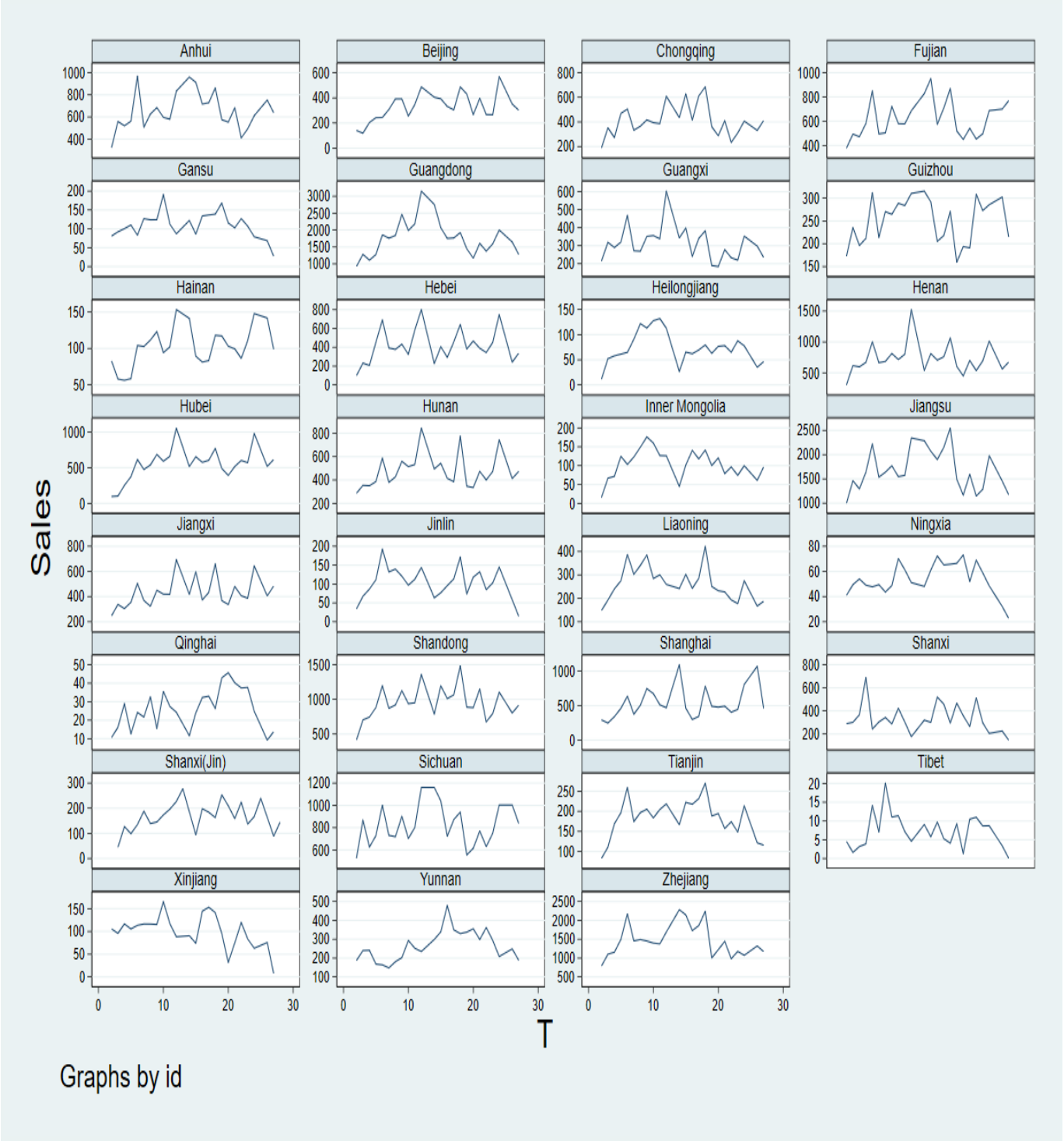
4.1.3 Dependent variable: Sales

In our research, we would like to take sales as our independent variable which reflects the variations and trends of demand in the Chinese residential housing market. There are three reseasons why sales is a more favourable independent variable than the others. Firstly, it can fit into the neo-classical model we would like to use for analysis in the later part. The sales are calculated as below:

*Sales = Average provincial prices per square * Total amount of squares that were sold within the certain period and province*

According to the formula, we can see that sales can reflect combinations of deviation from two dimensions, prices and quantity. And the complex effect enables us to have a better understanding of the change in the housing markets. Actually, from the historical data of the real residential property prices index for China issued by the Bank for International Settlements (2022), the average price of China's real properties, compared to a 5% average growth per year from 2006 to 2018, almost remain stable from Q4 2019 (which is 108.7458)to Q1 2022 (which is 109,3374). In that case, we can approximate the change in the total amount of squares by looking at the variations in sales. Figure 7 gives an intuitive overview of the dependent variables.

***Figure 7**: Scatterplot of provincial total sales of residential houses(100 million CNY) and time (monthly)*



Source: the National Bureau of Statistics.

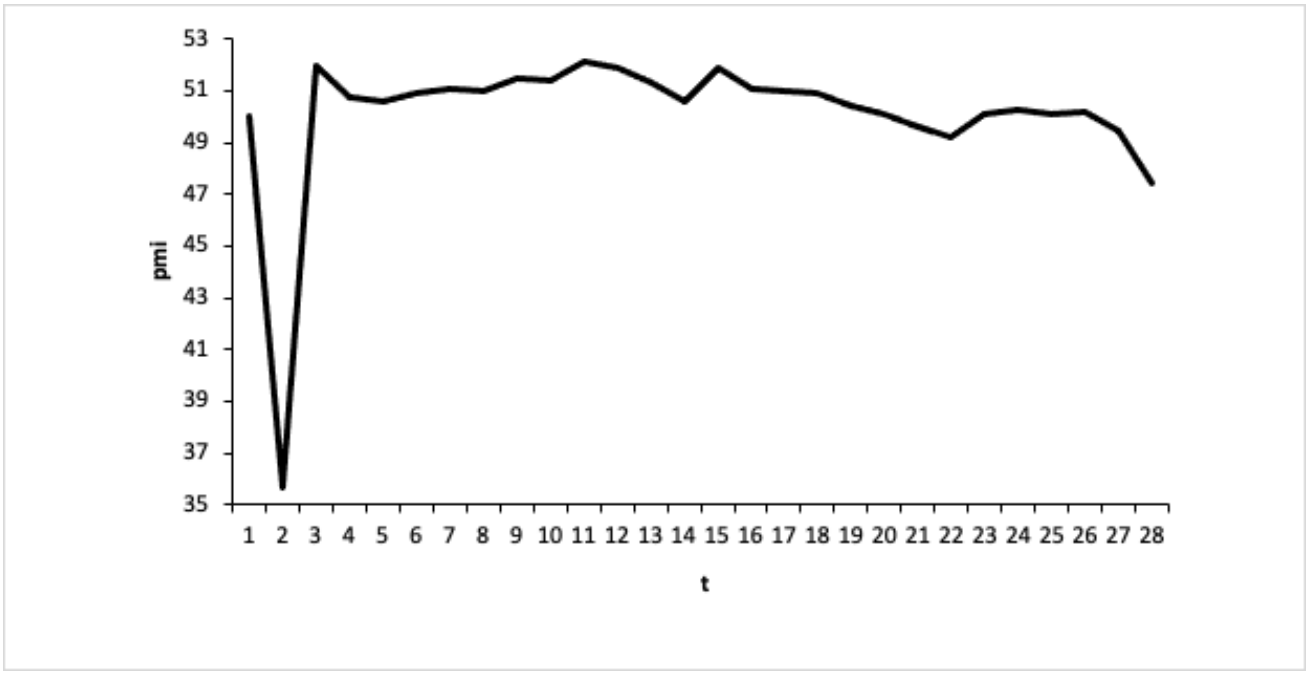
4.1.4 Economic indicators

The economic indicators as control variables in our model will be P/E value, unemployment and PMI. Usually, GDP is the most commonly used indicator to describe the status of an economy from the perspective of macroeconomics. However, in this research, GDP may not be an ideal indicator as the frequency cannot match with the other variables. In that case, we replace GDP in Wang & Zhang (2014) with the PMI index. Moreover, the other important role of Chinese residential housing is as an investment choice. To further control the impact of changes in investors' preferences for investment targets on this research, we introduce the average P/E value on the Chinese stock market as a control variable. In the following, we would like to introduce the three control variables in detail.

PMI

The Purchasing Managers' Index (PMI) is an index compiled from the results of a monthly survey of corporate purchasing managers. It is one of the leading indicators for monitoring macroeconomic trends in general, with strong forecasting and early warning functions. The PMI index is a composite index that reflects the output changes of the entire industry (manufacturing and non-manufacturing) in the current period. By definition, people see 50% as the dividing line between prosperity and decline in an economy. The value of PMI range from 0 to 100 with a unit of percentage. We collected the average PMI of 28 months for each province. The data is obtained from the National Bureau of Statistics. Figure 8 shows a line graph of the PMI.

***Figure 8**: PMI in China during the COVID-19 pandemic.*



Source: the National Bureau of Statistics.

P/E

Price Earnings Ratio is referred to as P/E or PER. The price-to-earnings ratio is the ratio of a stock's price divided by its earnings per share (earnings per share, EPS). Or divide the company's market value by the profit attributable to shareholders for the year. If a stock has a higher P/E value, it means the investors have a relatively positive expectation of the stock. Similarly, a higher average P/E value in a market shows the investors are optimistic about the economy, and more money has flown in. We obtain the monthly average P/E value of all stocks on the Shanghai exchange and Shenzhen exchange from the National Bureau of Statistics.

Unemployment

As mentioned in Wang & Zhang (2014), the unemployment rate is a significant fundamental factor affecting the residential housing market in China. We collect the data from the National Bureau of Statistics.

4.2 Statistical Summary

In this part, we show the two tables that include descriptive statistics of all the data we will use in this research. Table 1 gives the readers an intuitive overview of the data. We include observations, mean, median, standard deviation, minimum and maximum in table 9.

Table 9: *Statistical Summary*

Variable	Observations	Mean	Standard Deviation	Min.	Max.
Daily Infections	743	5527.7510	15360.53	142	68036
Sales	744	461.5180	489.5334	0.07	3150.76
Lockdown	744	0.2056	0.4044	0	1
PE	744	328.1057	48.8733	236.49	412.21
PMI	744	50.1790	3.0706	35.7	52.1
Unemployment	744	4.7693	0.4349	4.2	5.6

Source: the National Bureau of Statistics.

We also create correlation table 10 to show the level of correlation across different variables.

Table 10: *Pairwise Correlations*

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
(1) sales	1.000						
(2) PMI	0.105	1.000					
(3) daily infections	-0.099	-0.785	1.000				
(4) lockdown	0.024	-0.303	0.296	1.000			
(5) close contact	-0.084	-0.423	0.866	0.167	1.000		
(6) PE	0.037	0.184	-0.122	-0.122	-0.004	1.000	
(7) unemployment	-0.062	-0.300	0.436	0.083	0.271	-0.461	1.000

Source: the National Bureau of Statistics.

5 Results

5.1 Result

Table 11: *Relationships between sales and infections in different provinces.*

id	Province	Coefficient	P-value	id	Province	Coefficient	P-value
2	Qinghai	-237.0579	0.000	17	Anhui	389.5696	0.000
3	Jinlin	-159.4692	0.002	18	Guangdong	1495.711	0.000
4	Chongqing	146.0338	0.005	19	Jiangxi	171.1558	0.001
5	Xinjiang	-162.6996	0.002	20	Ningxia	-209.0079	0.000
6	Hainan	-160.3533	0.002	21	Shanxi	74.63042	0.149
7	Zhejiang	1205.589	0.000	22	Hebei	153.0863	0.003
8	Tibet	-255.9221	0.000	23	Hubei	288.9437	0.000
9	Heilongjiang	-189.0958	0.000	24	Fujian	357.3946	0.000
10	Beijing	65.98667	0.202	25	Sichuan	556.3654	0.000
11	Shandong	689.8542	0.000	26	Guangxi	49.2725	0.341
12	Shanghai	274.3958	0.000	27	Hunan	215.9013	0.000
13	Gansu	-152.9887	0.000	28	Tianjin	-78.99167	0.945
14	Inner Mongolia	-158.3771	0.000	29	Jiangsu	1415.176	0.000
15	Guizhou	-13.63958	0.792	30	Yunnan	3.586252	0.000
16	Shanxi(Jin)	-95.81911	0.064	31	Henan	467.2638	0.000

Source: the National Bureau of Statistics.

Since the economic status and economic development patterns of different provinces in China are significantly different, and this difference may have an impact on the results of the study. So we need to test our first hypothesis. Namely, the impact of the COVID-19 pandemic on different regions is different. If this effect is insignificant or the variations are not extremely different for the coefficients, then we can consider it reasonable to use a fixed-effects model. Table 11 is the result of the fixed effects model of sales and infection cases of different provinces. We set Liaoning province (province_id = 1) as the baseline. As we can see from the table, the results are statistically significant for most provinces and compared to the average coefficient. The variation is relatively small. In that

case, we conclude that the first hypothesis cannot be rejected, and we can apply the fixed effects model with our panel data.

Table 12: *Province Fixed-effects Model Results*

Sales	Direct	Indirect	General
Lockdown		-85.05753 ***	-91.39148***
		(0.000)	(0.001)
Infections (lag 5 periods)	-18.04032 ***		-18.46702***
	(0.001)		(0.000)
PMI	36.4118**	9.159451***	35.10473**
	(0.017)	(0.001)	(0.019)
P/E	.3338089	.2842866*	.3504595**
	(0.118)	(0.091)	(0.095)
Close Contacts	-.0000196 **	-.0000115**	-.0000172 **
	(0.025)	(0.032)	(0.046)
Unemployment	84.59406**	-18.29188	80.52868**
	(0.038)	(0.332)	(0.044)
Constant term	-1840.46 ***	24.66771	-1746.208 ***
	(0.006)	(0.890)	(0.004)

Note: There are 31 groups and 743 observations. All the data are collected from the National Bureau of Statistics. Within R-square for the first column is 0.1025. Within R-square for the second column is 0.1272. Within R-square for the third column is 0.1370. The number in the parentheses indicates the standard error type I of estimate. * indicates p-value<0.1, ** indicates p-value<0.05, *** indicates p-value<0.01.

According to the first column of table 12, every 10 thousand new infected cases of COVID will negatively influence the sales of the residential housing market in the local market by 18.04 million CNY after five months. The result reaches a significance level of 5% and can be regarded as statistically significant. So we cannot reject our second hypothesis, which is the pandemic has a direct negative impact on the residential housing market size.

We move on to investigate the relationship between the impact of lockdowns on sales. From the second column, we see that if other variables remain, lockdown will lead to an immediate negative impact on sales. Every lockdown will influence the sales negatively by 85.058 million CNY. The result is also statistically significant. Such a result supports our third hypothesis, which is the hard lockdown policy has a significantly negative effect on the residential housing industry in China.

In the end, we would like to combine the two models to give out a general model, people may use to predict or evaluate the impact of the pandemic on residential housing sales. As shown in the third column, except for P/E, all results are statistically significant. We explain it as the investors' behaviour in the stock market does not significantly affect their investment in the real estate market, so the P/E value does not significantly affect total residential housing sales. In that case, our fourth hypothesis is rejected.

5.2 Time Robustness

In the previous part, we explain that we choose a lag of 5 months as our main explanatory variable for studying the direct impact of the pandemic. However, we may suffer from omitted variable bias if we only focus on one period. In that case, we replicate our model with different time lags. The results show that lockdown and daily infections still have significant negative effects on sales for lag 4 periods, 6 periods and an average of 4 to 6 and 3 to 7 periods. The model does not reach the significance level for lag 3, lag 7 and any other periods farther away from period 5. Such a phenomenon may be because the spread of the virus is usually continuous progress but not a sudden outbreak. Lag 5 periods is the most explanatory time lag, but the periods closer to lag 5 are also with closer infections and other economic indicators. In that case, lag 4 periods and lag 6 periods are also statistically significant but are less powerful than lag 5 periods. We may conclude that our models are robust to a wider time range but do not work for periods far away from 5 periods. The results are shown in Table 13.

Table 13: *Province Fixed-effects Model Results with other lags*

Sales	General	R square (within)
Monthly Infections (lag 3 periods)	-.0004 (0.522)	0.1198
Monthly Infections (lag 4 periods)	-.0017 *** (0.002)	0.1307
Monthly Infections (lag 6 periods)	-.0010 ** (0.033)	0.1300
Monthly Infections (lag 7 periods)	-.0007 (0.171)	0.1375
Average Monthly infections (from T=4 to T=6)	-.0013533 *** (0.000)	0.1430
Average Monthly infections (from T=3 to T=7)	-5.695906 *** (0.002)	0.1353

Note: There are 31 groups and 743 observations. All the data are collected from the National Bureau of Statistics. The number in the parentheses indicates the standard error type I of estimate. * indicates p-value<0.1, ** indicates p-value<0.05, *** indicates p-value<0.01.

6 Conclusion and Discussion

6.1 Limitations

Hill et al. (2019) describe the multiple limitations we may have in our fixed-effects models for panel data. We may suffer from the following limitations in our research:

6.1.1 Limited external validity

Hill et al. (2019) reckon that when the analysis sample is not a good representative of the population, the p-value is less statistically and practically meaningful because it is not clear how to assess the probability of a relationship in the population when the population itself is undefined. Nonetheless, Jeffrey Wooldridge (2010) explains the fixed effects methods can lead to inaccurate estimates in cases

where the key variables do not change much over time. We may be forced to use random effects estimates to know anything about the parameters of the population. But according to the result of the Hausman Test before, the fixed effects model is more likely to be accurate in our research.

6.1.2 Restricted Time Periods

Due to the duration of the pandemic, we only have data of limited time periods. As claimed by Nickell (1981), " a typical set of panel data has a rather large number of individuals and a rather small number of time periods ". But in our dataset, the number of time periods is way more than our individuals. In that case, our fixed effects can be more biased than the research with city-level data.

6.1.3 Measurement Error

Measurement Errors in our dataset usually come from misreporting. Falsification of economic indicators in certain provinces in China is very common, sometimes with large adjustments several years after the data is released. For instance, as reported by Sina Finance (2021), Tianjin has experienced an economic decline for a long time, but local officials have chosen to hide the truth from the public. But the government is under increasing financial pressure, which they can never afford. In 2021, Tianjin made a significant adjustment to the economic data for 2020, in which the GDP was reduced by more than 70 billion US dollars. Similar measurement error also occurs in the statistic of daily infections.

6.2 Conclusion

In this paper, we firstly go through the historical development of the Chinese real estate market, and existing research on how the pandemic and other natural disasters affect real estate and summarized several potential factors that may show a great impact on the market. We also investigate the effect of the COVID-19 pandemic on residential housing sales in China using a fixed-effect mode. We focus on the direct impact and indirect impact caused by prevention measures. From the empirical analysis, we found that the increasing number of infected cases has a significant negative effect on sales.

Then we analyze the effect of the most common restrictive measures in China, hard lockdown, on sales. Based on our results, we conclude that hard lockdowns have significant negative effects on sales. By comparing the direct impact of the pandemic and the secondary effect caused by the prevention measures, we can see that the impact of the lockdown is almost four times higher than the 10,000 new infections, and the level of significance is also slightly higher than the direct impact. In addition, the impact of the lockdown is immediate, while the immediate impact usually takes five months to manifest. Moreover, we should not ignore what we mentioned above. Usually, several new infections in an area can make the government lock down the city.

All in all, our answer to our central question in this paper is that the COVID-19 pandemic has both a significant negative direct impact and an indirect impact through prevention measures. Among the two aspects, the restrictive hard lockdowns have a more significant impact.

6.3 Discussion and Suggestions

From the beginning of the epidemic to the present, many countries have never stopped politicising the epidemic, including China. At first, the Chinese government quickly controlled the world's first wave of the COVID-19 epidemic with its centralised political system and high social mobilisation ability. In order to consolidate its own epidemic prevention results, China has begun to take the most stringent COVID epidemic prevention measures in the world. Although the pathogenicity of the virus itself has gradually weakened in recent years, China's epidemic prevention measures have become more stringent. We can also see from our data that the number of lockdowns in late 2021 has increased substantially. At the same time, we cannot ignore that as the number of lockdowns increases, the national unemployment rate also begins to increase. Although we did not examine the causal relationship between the two in this study, we cannot ignore that the lockdown did cause a large number of highly leveraged SMEs to go bankrupt and countless jobs to disappear as a result. At the same time, due to the short-term imbalance of supply and demand in the market for daily necessities due to the closure of the city, high prices have further drained the wealth of the people, but it has allowed a small number of people to benefit from it, which further aggravates social inequality.

According to the latest data, China's GDP growth rate in the first half of 2022 reached its lowest level in 1990 (Financial Times, 2022). The most direct cause of the official explanation is the epidemic. However, the direct impact of the epidemic on production has been proven to be far less harmful than the epidemic prevention measures brought by the closure of the city. And China is also the only country on the planet that is still taking measures to deal with the epidemic. Our findings show that the lockdown significantly negatively impacts the real estate market. Other studies have also shown the damage to most industries from the lockdown. Even for some foreign trade-based industries, this kind of damage is irreversible. Financial Times (2022) believes that the Chinese government's actions are mainly for political purposes, that is, to maintain its own epidemic prevention achievements before the reelection of the Chinese Communist Party in 2022 to add to its political achievements. We suggest that the Chinese government re-examine its anti-epidemic policies, and we do not suggest that the economy should be sacrificed to achieve its political goals.

For future research, we firstly suggest other researchers can add more economic indicators to enhance the explanatory power of the model. For instance, we did not consider the change in customers'

sentiment, but previous research shows that customers' sentiment usually causes variation in the housing market. Secondly, we only focus on the Chinese housing market in this research. Even though the Chinese housing market has some unique characteristics, our research methods can be applied to other countries or markets. Thirdly, the pandemic has not come to an end yet, so our model may not be valid in the future. We suggest future researchers can complement our model with up-to-date data on this pandemic.

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