The Impact of the COVID-19 Pandemic on Rents in the city of Seattle limits

Jianxia Zhu

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Sofia Dermisi
Arthur Acolin

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Abstract

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Chair of the Supervisory Committee:
Sofia Dermisi
Department of Urban Design and Planning

The thesis examines the extent of changes in rents during the COVID-19 pandemic at the zip code level for the city of Seattle using statistical analysis and Geographic Information Systems (GIS). The results of the study suggest there is an average decrease in rents by 6% in the study area during COVID-19 compared to 2019. Five zip codes saw a rent decline over 10% with the greatest decrease reaching 17.5%. These zip codes are located in the core of the downtown area. In terms of socioeconomic characteristics, these zip codes have high population density, high-tech employment, working-age population (18-34), and renter-occupied units rate. There is no direct correlation between the rent change and COVID-19 cases or positive rate at this level. The secondary impact of the pandemic such as work from home policy, the subsequent migration of residents, and the decline in the attractiveness of the city center are the actual reasons that affect rents.

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Acknowledgement

I am very grateful to my mentors for their help in my studies in both urban planning and real estate professional studies. Thanks to Sofia Dermisi and Arthur Acolin for reviewing my thesis and guiding my research. They answered my questions carefully and shared their insights, which helped me establish the research. I am especially grateful to Sofia as my program mentor for her patient guidance and help during my two years of studies.

1. Introduction

The COVID-19 pandemic is an external shock the world has not seen since the Spanish flu pandemic. The pandemic not only affected people's lives but also shocked the local and global economies. The action and response speed to the pandemic varied from country to country, with people being affected negatively worldwide. Although the discovery of the virus was reported to the WHO in late January 2020, most countries didn't realize its significance until late March when tens of thousands of people were being infected daily, and actions were needed urgently. That's also when the market started to be greatly affected. GDP and employment in the US, as indicators of the economy, sharply declined in the first two quarters of 2020, reaching the lowest point since 2008 in the second quarter. Renigier-Biłozor et al. (2020) suggest that the negative consequences of the COVID-19 pandemic on the real estate market could be substantial, and the level of crisis is not predictable, regardless of the country or even the region. The thesis assesses the effect of the COVID-19 pandemic on rental real estate markets within the City of Seattle. Many scholars are currently analyzing the effect of the pandemic on our activities and real estate markets. Kuk et al. (2021) examined how the rental market in the 49 largest metropolitan areas in the U.S. was affected in the first few months of the COVID-19 pandemic and found a clear dip in average asking rental prices for all metropolitan areas from March through mid-April. Arpit et al. (2021) found that the COVID-19 pandemic is flattening the bid-rent curve of house price and rent in most U.S. metropolitan areas. In this widely negative economic background, the real estate sector is actually facing a great challenge with a close relation to those economic industries.

Considering the difference between rental and for sale properties, the long-run development of both types is useful. Some reports suggest a positive perspective from the investment side (BridgeTower Media Holding Company, LLC, 2020; NewsRX LLC, 2020). But little detail is known about how the rental housing market responds to external shocks such as a pandemic.

This thesis explores rents before and during the COVID-19 pandemic. At a microeconomic level, understanding the Seattle rental housing market responses to COVID-19 can help us identify the resilience of the city with a core of tech workers and a significant rental market presence of more than 50% (Seattle Times, 2021). Liu & Su (2021) found that the pandemic has led to a demand shift away from high population density neighborhoods. As the rental housing market is sensitive to such a demand shift, the research focuses on the demand side and tenants' reactions to the pandemic within the city of Seattle limits. This study can be helpful in understanding the rental housing market resiliency during the pandemic and possibly used as a historical reference for future pandemics or similar situations.

The thesis objective is to answer the following research questions:

1) ***How did the rental housing market within the city of Seattle respond to the COVID-19 pandemic?*** And
2) ***What are some of the factors associated with the decline in rent over the last year in Seattle?***

The results of the study suggest the shock in the local rental market may have additional underlying reasons, which the COVID-19 pandemic made worse and contributed to a demand shift away from the city center.

The thesis is organized as follows. Section 2 focuses on the relevant literature. Section 3 describes the methodology of the research based on Geographic Information Systems (GIS) and statistical analysis. Section 4 provides a detailed analysis and comprehensive analysis within the study area. Section 5 concludes the findings and some limitations of the study.

2. Literature Review

The literature review provides a context based on current pandemic-related research and some responses of the real estate market to the COVID-19 pandemic. This literature can help understand the impact of a pandemic on the rental housing market in three sections: the COVID-19 preliminary impact on the real estate market, responses to the COVID-19, and the Seattle Market.

2.1 Impact of COVID-19 on Real Estate Market

Media, professional reports, and academic research have laid the foundation for further exploration of the impact of the COVID-19 pandemic, in two areas: on the *macroeconomy* and on *specific market sectors such as real estate.* The COVID-19 pandemic is still a worldwide threat due to continuous variants, different domestic policies. Nicola et al. (2020) summarized the socioeconomic effects of COVID-19 on individual aspects of the world economy including the real estate sector. Del Giudice et al. (2020) pointed out that the real estate market will not move independently from the context of great changes in those macro-economic variables such as decreasing consumption and increasing unemployment. The authors tried to explore the effect of pandemics or health emergencies on housing markets by comparing the real estate dynamics and economic indicators of the Campania Region in Italy before and during COVID-19 and developed a model that indicates a housing prices drop of 4.2% in the short-run and 6.5% in the mid-run (late 2020–early 2021). Dotzour (as cited in HomeVestors, 2020) predicted a long-term migration to the suburbs as a direct result of COVID-19 because companies have broadly embraced work-from-home arrangements and therefore previous home buying considerations like concerns about

commutes will fall in importance. The impact of this migration on the rental housing market is the same as proved by the following great rent decline in the core area of large cities.

COVID-19 is not the first disaster with a worldwide effect. We can learn lessons from historical natural disasters, especially previous worldwide pandemics such as H1N1. Based on the 2009 H1N1 pandemic, Luckhaupt et al. (2014) found that the prevalence of influenza-like illness negatively affected the “Real estate and rental and leasing” sector by 10.5% and “Accommodation and food services” sector by 10.2%. Both seasonal influenza and H1N1 vaccination coverage were relatively low among workers in these industries. Their findings indicate that industries including real estate are vulnerable to a pandemic. Santos et al. (2009) emphasized the criticality of workforce availability in the aftermath of a pandemic. The authors provided an insight on workforce availability in different economic sectors responding to pandemics in the background of the H1N1 pandemic. They saw a pandemic as a unique disaster because the majority of its direct impacts are workforce-related. Barro et al. (2020) compared the economic effect of COVID-19 with the Great Influenza Epidemic (Known as Spanish Flu), which peaked in 1918 and persisted through 1920. Their regression analysis indicated a substantial effect of the pandemic death rate on the GDP and consumption. Different from the previous pandemics, the COVID-19 has a stronger widespread impact and a different background of social economy and technology that provide more choices for individuals.

An increasing body of research is examining the effect of COVID-19 on the real estate market. Consumption sectors such as restaurants saw a sudden drop in visits (Cox et al., 2020, as cited in Liu & Su, 2021). Kuk et al. (2021) suggested both spatially and racially

unequal effects of the COVID-19 pandemic on neighborhoods of different income levels or races. They found that the overall downward trend of asking rents is driven by drops in Black and Latino neighborhoods while white neighborhoods experienced price increases in the first few months of the pandemic. They highlighted distinct mobility patterns, the extent of racial segregation, and local COVID-19 related ordinances as the factors that likely caused the variation across metropolitan areas. Gupta et al. (2021) found that rents decline in city centers and increase away from the center. Rents in the suburbs rose much faster than rents in the center between December 2019 and December 2020. They explain this phenomenon by the flattening of the bid-rent curve happening in most U.S. metropolitan areas as an impact of the pandemic. Tanrıvermiş (2020) examined the possible effects and impacts of the COVID-19 outbreak on real estate development and management processes by making an evaluation and an insight into administrative and media records. The study found that there has been an increase in the demand for land for production and settlement in rural areas in Turkey. Similarly, Arpit et al. (2021) found that the COVID-19 pandemic led many residents to flee city centers in search of safer ground away from urban density. This trend made the rents in the suburbs rise much faster than rents in the center over 2020, and therefore was flattening the bid-rent curve in most U.S. cities. Alexandri and Janoschka (2020) identified the rent gap as an analytical tool to understand dispossession, and the corresponding displacement of people, practices, and discourses when studying post-pandemic gentrification.

Some researchers have found some potential factors that can help to explain the rent decline amid the pandemic. A report by Deloitte (2020) explained the impact of COVID-19 on tenants with the liquidity pressures that can be one of the factors leading to the

movement out of city centers with high rents. Rosenthal et al. (2021) conclude many potential causes of the change in rent including an increase in the cost of interaction because of contagion risk, a decrease in the benefit of interaction because of the reduced density of business districts, a decrease in productivity of physical infrastructure such as subways, and a newly discovered ability to work from home. Kuk et al. (2021) explain differential rental market trends by heterogeneity in COVID-19 case rates at the metropolitan area level with New York City and Los Angeles as samples. There is still a gap in the literature to examine the impact of COVID-19 on the local rental housing market at a microeconomic level within a city.

2.2 Responses to the COVID-19 pandemic

Many scholars are exploring the evolving trends based on what the COVID-19 pandemic has brought to cities. Gujral et al. (2020) highlighted COVID-19 is a humanitarian challenge that will have lasting effects on how people live, work, and play. The authors raised two valuable questions to urge people to rethink the future of real estate: Will employees demand larger and more enclosed workspaces? Will people decide not to live in condominiums for fear of having to ride elevators? Judging from the current trend of moving out of the city center in 2021, the answers are probably yes.

In 2020, the social distance requirements forced many companies and organizations to accept the transition to remote work. Work from home became human society's major response to the COVID-19 pandemic. Ramani & Bloom (2021) found the "Donut Effect"

brought by the COVID-19 pandemic on large cities across the U.S. reflecting the movement of activity and demand out of city centers to the suburban ring. They found households, businesses, and real estate demand have moved from dense central business districts (CBDs) towards lower-density suburban zip-codes within large cities. De Fraja et al. (2021) refer to this geographic shift in productive activities as the Zoomshock. They established three facts that: a) Zoomshock is a large phenomenon that affects a large population; b) Zoomshock is extremely heterogeneous with the most prominent feature from the city center to the suburbs, while the opposite in a few neighborhoods; c) Zoomshock is moving workers away from neighborhoods with a large supply of locally consumed services to neighborhoods where the supply of these services is relatively scarce. Delventhal et al. (2020) saw the far-ranging consequences regarding the distribution of economic activity inside urban areas. They found three important effects of working from home: a) jobs move to the core of the city while residents move to the periphery; b) traffic congestion eases and travel times drop; and c) average real estate prices fall, with declines in core location and increases in the periphery. One of the benefits of working from home during COVID-19 is highlighted by Fadinger and Schymik (2020), who found it very effective in reducing infection risk. Surveys from Davis et al.(2021) suggest that once the pandemic subsides, workers expect to approximately triple their time spent working from home relative to pre-pandemic levels. They expect work-from-home, as the consequence of the COVID-19, to increase productivity by 46% during the pandemic and have a permanent change in the future. Gupta et al. (2021) explained that the ability or indeed the necessity to work from home greatly facilitated the urban flight of residents fleeing city centers. They saw zip codes close to the center of the metro area lost population while suburban zip codes gained people, and therefore the places that experienced the strongest migration that experienced the largest

rent changes. They also found that zip codes with higher exposure to work from home see lower rent growth within the same metropolitan area so they suggested that work from home as a key factor driving the empirical patterns in rents.

2.3 The Seattle Market

Seattle as one of the coastal U.S. cities with increasing size has seen a strong rental housing market. According to Trulia.com Rent vs. Buy Index (2010), the price-to-rent ratio of Seattle was 31, the second-highest city in the U.S. with New York city being at first place. The price-to-rent ratio over 21 was interpreted as that the total costs of owning a home in this city are much greater than the costs of renting. Zhai & Peng (2021) researched the real estate market amid COVID-19 using this index. Their latest price-to-rent ratio suggests that people should not buy a house in coastal cities including Seattle. Seattle is still one of the top cities with the highest ratio even during the COVID-19 pandemic. Zhai & Peng suggested that a relatively higher price-to-rent of those coastal cities can indicate that it is better for residents to rent rather than buy a house there. Seattle, as a market with a high price-to-rent ratio, was greatly affected during the COVID-19 pandemic. The Seattle rental housing market is experiencing a great challenge due to the COVID-19 pandemic. "Expensive coastal cities such as San Francisco, Seattle, and New York City are continuing to see rents fall rapidly, while traditionally affordable mid-sized cities such as Boise have actually become more expensive over the course of the pandemic." As the Apartment List National Rent Report (2021) said, rent prices of Seattle in December 2020 have dropped 22% since the start of the pandemic in March. And Seattle rent prices declined the second-fastest among the country's 100 largest cities, second only to San Francisco with a drop rate of 26.7%.

In fact, Seattle was facing a series of socioeconomic changes even before the outbreak of the COVID-19. The protests and riots, the urban decay, the high living costs, and homelessness all can be the background of the Seattle market. A national study (as cited in Balk, 2019) ranked Seattle, among 100 large cities in the U.S., third for the degree of gentrification since 2000. Westneat (2021) found the number of households leaving the city in the year 2020 soared by 36% relative to the year before. He also pointed out the large net migration out of the city was more than 26,000 households and a potential 7% decline to the total 351,000 households according to the change of address data provided by the U.S. Postal Service. He believes that Seattle's shrinking phenomenon is the reason for the current availability of 12-weeks-free concessions for apartments.

3. Research Method

3.1 Methodology

The thesis focuses on the impact of the COVID-19 pandemic on the local rental housing market of Seattle in 2020. This is descriptive research based on existing literature and data. Because the purpose of this research is to explore the impact of the 2020 COVID-19 pandemic on the rental housing market. COVID-19 is not the first or the only pandemic that hit modern human society. The basic reproductive rate $(R0)$ for Covid-19 is 2.5, which is higher than the Spanish flu 0.9 and MERS 1.5 and more focal dissemination (Petersen et al., 2020). The impact of a pandemic similar to COVID-19 can be a recurrent theme in the future. Therefore, in addition to exploring the impact of the COVID-19, this research could also serve as a reference when a similar outbreak occurs in the future.

The research tries to answer the question:

1) ***How does the rental housing market within the city of Seattle respond to the COVID-19 pandemic?*** And
2) **What are some of the factors associated with the larger decline in rent over the last year in Seattle?**

As the study area is the city of Seattle, an effort was made to collect open-source data at the lowest possible geographic level available, which is the zip code. The research uses multiple data sources, including open source and public databases as well as reports. It starts with a collection of the latest reports on the valuation of the residential real estate rental market in the current condition, based on local professionals. The data collection included quantitative

data (current and historical) on the residential real estate market, public health, and socioeconomic trends, providing the foundation for this research. The data periods include both pre-COVID and during COVID trying to assess the impact on the rental housing market. The thesis is based on a systematic collection, organization, and interpretation of the area residential rental market and socioeconomic conditions. The two methods used to analyze the dataset were Geographic Information System (GIS) analysis and basic statistical analysis. Within the study area of the research, we select the zip code areas with the most severe changes in rents affected by the COVID-19 pandemic over 2020 as the focus areas. We explore the differences between the focus areas and other areas to identify the impact of the pandemic on the local rental housing market and the factors of that change.

GIS allows us to identify patterns based on the spatial distribution of our data. The patterns obtained from GIS analysis can show the market and social characteristics of the study area and the market dynamic. At the zip code level, we can examine changes in both the submarkets with different microeconomic backgrounds and the entire Seattle market based on internal market rules. The research integrates all the public health, real estate market, and socioeconomic data into GIS and provides some emerging spatial patterns. We describe the patterns to see how the COVID-19 pandemic affects the local market and explore the potential connections between the data from pattern features. With the capacity of GIS, the research can reveal deeper insights into the data and the research questions. The descriptive research through the visualized patterns from GIS is used to answer the first question that how does the rental housing market within the city of Seattle respond to the COVID-19 pandemic.

In addition to the descriptive GIS analysis, we make further statistical analyses to explore the exact relationship between the variables. Some charts and tables are used to discover the degree and regularity of market changes supporting the impact of the pandemic. We use correlation analysis and t-tests to confirm that impact and find out specifically related factors. The correlation analysis focused on the association between the rent change rate over 2020 and other variables from all aspects. T-tests examine the differences between the focus areas and other areas to identify the potential reasons for the different levels of impact on different spatial locations. The basic statistical analysis is used to answer the second question, that is, what are some of the factors associated with the larger decline in rent over the last year in Seattle.

In microeconomics, the balance between supply and demand determines the market pricing of goods. This is the basic principle which explains the rent change in the real estate markets. When more people are willing to pay the rent in a certain market with not enough supply of apartments, the rents will increase. On the contrary, when more apartments are available than potential renters, the rents will decrease. The reason the rental market was affected by the pandemic can always be explained by people interested in lowering the cost of living as they were working from home and did not need to be close to their jobs in areas with higher rents. Gupta et al. (2021) indicate that workers with the capacity to leave cities did so, reshaping housing values both in prices and rents towards suburban areas at the cost of urban ones by linking migration data to remote work. One influential economic theory improved from the Bid-rent theory (Alonso, 1964; Muth, 1969) explains the rent difference between locations by the trade-off between transportation cost and housing cost. Usually, central locations provide the best trade-off between commuting and housing costs. Renters

are usually more dependent on location and transportation cost and are particularly vulnerable to hardship while the pandemic will increase that vulnerability. (Choi et al., 2020) During the COVID-19 pandemic, this theory can be well applied to explain the reasons for changes in rental prices from the perspective of transportation costs.

The professional reports indicate that Seattle's rental housing market is experiencing great shocks during the COVID-19 pandemic in 2020. The report from ApartmentList shows that Seattle rents declined 3.6% month over month in December 2020, and was down 22% since the start of the pandemic in March with the data provided (https://www.apartmentlist.com/research/national-rent-data). The pandemic is a significant factor, but more microeconomic-level research is needed to explore what submarkets are most affected. The focus of this thesis is Seattle as the area has seen the second-fastest rent prices decline among the country's 100 largest cities (Salviati et al., 2021). So the research will delve into Seattle's smaller division by Zip Code to explore variations in the impact of the pandemic across neighborhoods. We use the rent change during COVID-19 to infer renter demand trends.

The thesis will provide a first assessment of the impact of the COVID-19 pandemic on the rental housing market within the city of Seattle limits.

3.2 Data

This study focuses on the residential rental market and socioeconomic conditions at the 5-digit Zip Code Geographic level within the city of Seattle limits. The data used in this research are open-source from various reliable platforms including government databases and some private real estate companies. The data contain two critical elements: Rental Market values and Public Health data (COVID-19). The zip code level is used to allow for the cross-reference of all the different datasets and better representation on a GIS map

Study Area

The study area contains 20 zip codes in the city of Seattle. The choice of the study area is based on data availability for all the data collected from the real estate side (rents, supply & demand), public health (COVID-19 trends), and socioeconomic data. The study area focuses on the downtown core of Seattle. The selected zip codes highlight the impact COVID-19 had in the main Seattle core.

Figure 1, shows the zip codes within the city of Seattle city limits studied as well as those without data availability. Among the 20 Zipcode study areas, the 5 zip codes with the greatest decline in rent with more than a 10 percent decline between Jan. 2020 and Jan. 2021 form the focus area highlighted with the red borderline. These zip codes are worthy of a separate and detailed analysis to explore factors that may explain their greater decline in rent prices.

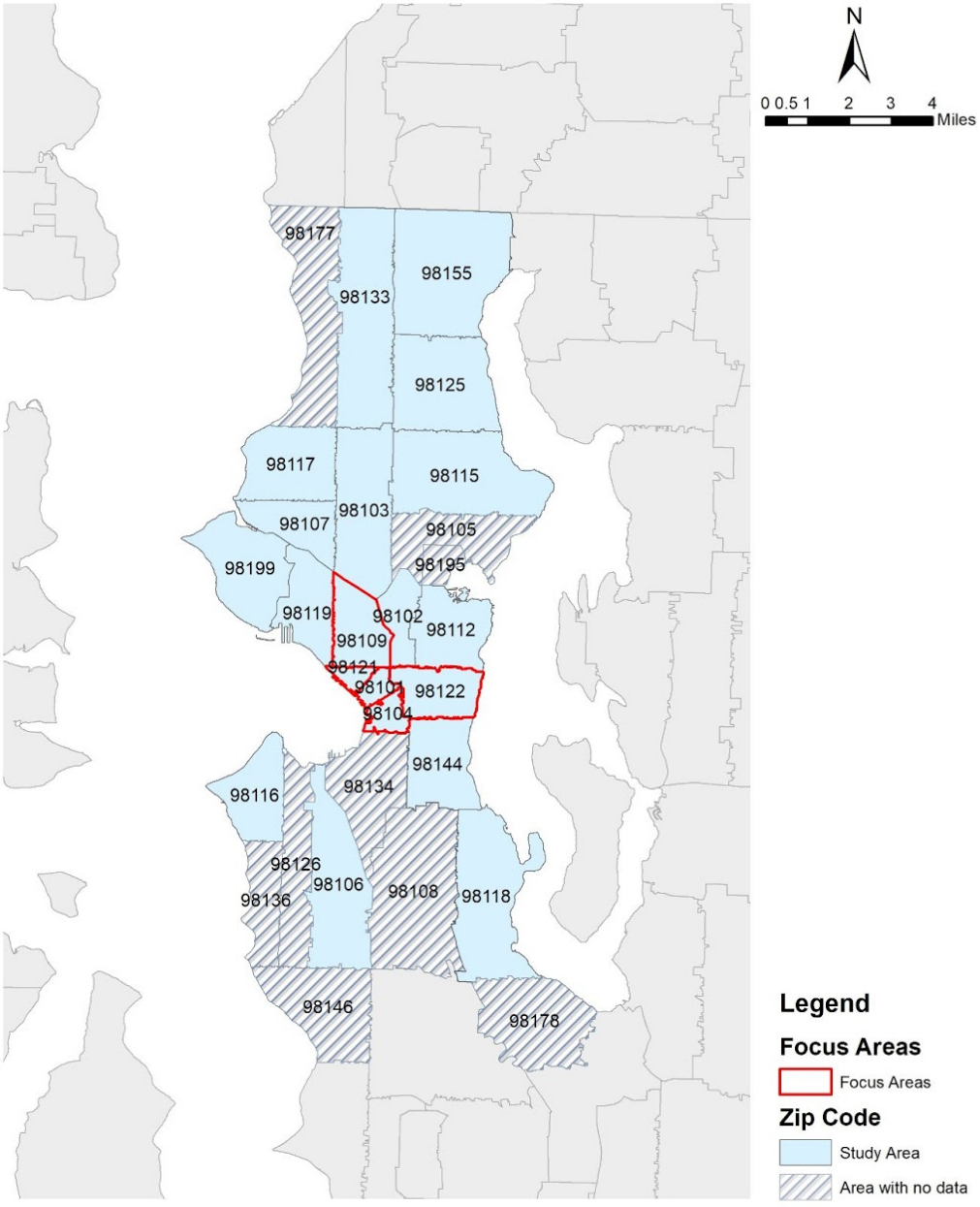

Figure 1 Map of the Study Area

Rental Market Variable

The rental market data was collected from Zillow, which is a virtual residential marketplace in the United States (https://www.zillow.com/research/data/). It has a research site allowing researchers to utilize their data for academic research for free. It provides rental data as Zillow Observed Rent Index (ZORI) based on various geographic levels including Zip Code. The database covers the United States and is updated monthly, which is very helpful for the research on the impact of Covid-19 on the rental market. The recorded rental price is the price at the beginning of the month. As of the research period of the thesis, the latest data is January 2021 and covers the whole calendar year 2020. However, the data also has a major limitation since it doesn't cover all zip codes. The possible reason for this problem might be the limitation in Zillow's own market data and the fact that some areas have limited rental stock. But it can still cover most areas and give us an overview of the target market. The study uses data from the last 3 years (2019-2021). All the rent price data are reported on the first day every month. We pick the rent on the first day of the year to calculate the annual rent change. By comparing the rent on Jan 1st 2019, Jan 1st 2020, and Jan 1st 2021, we can get the annual rent change over the year 2019 and 2020, which are the most important variables in the research as the key indicator of the local rental market.

Public Health Data- COVID-19

COVID-19 cases data is the direct indicator of the number of people infected by covid. Authoritative research centers such as John Hopkins University provide COVID-19 data to the public and keep it updated daily since the outbreak of the pandemic. Though the data is

clearly tracking the impact of COVID-19, they don't narrow the research area to the zip code level. The best resource for COVID-19 data is the daily COVID-19 outbreak summary from the King County government website (https://kingcounty.gov/depts/health/covid-19/data/daily-summary.aspx). The King County government provides cumulative positive cases, positive rate, hospitalizations, death, and other more data by 4 different geographic units in King County: city/town, Health Reporting Areas (HRA), Zip code, and census tract. The research uses zip code level data and focuses on the city of Seattle. Among the detailed data provided, positive cases and positive rates are supposed to have a major impact on the market change and people's decision on living choices rather than hospitalization or death in a certain location. According to the official definitions by King County:

Positive cases refer to the count of unique King County residents who have had a confirmed positive COVID-19 PCR laboratory result reported to the Washington State Department of Health. The positive rate refers to the rate of positive cases (count of positives divided by total population) among residents of each geographic area. For zip code and census tract, the positive rate is reported as positives per 1,000 residents. The data record started from February 1, 2020. The research takes the data from 2020.2.1 to 2021.1.1 that would have a potential impact on the rent price reported on January 1, 2021.

Socioeconomic Data

Beyond the rent trends extracted from Zillow, new housing unit permits issued and completed are used as supply indicators. The data are extracted from Seattle Open Data (https://data.seattle.gov/Permitting/Building-Permits/76t5-zqzr). We pick only the data in a Current Status as issued or completed for the selected 20 zip codes. The permit type is limited to Building and the time period is from 2020.1.1 to 2020.12.31. Only the Housing Units Added data is used in the calculation. The permit issued change rate and the completed rate is based on the comparison between the overall Housing Units Added in 2020 with the units in 2019. The rates can tell a potential trend of housing supply change amid the COVID-19 pandemic.

Usually, change in population is used as the indicator of demand, but there is no precise data for only the year 2020 at present because the census is ongoing during the pandemic and the data has not yet been released. The estimated population data will have a great difference from the real one due to the unexpected outbreak of the pandemic. So the demand data has few references but can only use the latest population data from King County Government (https://kingcounty.gov/depts/health/covid-19/data/daily-summary.aspx). These 2019 King County population estimates at the zip code level are obtained from the Washington State Office of Financial Management (OFM). The research calculates the population density for each zip code within the study area to identify the more reliable demand for the areas of different sizes. The age data is from IPUMS NHGIS (https://data2.nhgis.org/). The original data is grouped by 4 age groups: 0-17, 18-34, 35-59, 60+. We add up both the male and

female data for each age group and then divide it by the total population to get the percentage of each group. 18-34 is the early working-age group which is the group that may be most relevant to the research since more likely to be renting.

The tenure condition of the research areas can represent the sensitivity of the rental housing market. The housing units are occupied by either owners or renters. If the proportion of renter-occupied units is high, the area is more sensitive to any impact on the rental housing market. The research uses the percentage of renter-occupied units as an indicator of the areas' socioeconomic characteristics. The tenure occupancy data is obtained from IPUMS NHGIS (https://data2.nhgis.org/) .

4 FINDINGS & INTERPRETATION

4.1 GIS analysis

The thesis's first research question asks: ***How does the rental housing market within the city of Seattle respond to the COVID-19 pandemic?***

The annual change rate for 2020 (January 2020 to January 2021), can directly show the impact of the pandemic on the rent price. Most areas experienced a decrease for the year 2020, and five of the areas presented a decline of over 10%. These five zip codes experiencing the decline are adjacent to each other and concentrated in the geometric center of Seattle with three (98121, 98101, and 98104) being known as the Downtown core (Fig. 2 and 3). Zip code 98121 was the one with the more sizable decrease of 17.5%. Only three areas experienced positive growth rates. On the contrary, the change rates for all the study areas over the year 2019, from January 2019 to January 2020, are positive and mostly between 2.6% and 5.0%. Zip code, 98109 saw the second-largest rent increase at 5.22% over 2019. But then in 2020, 98109 dramatically became one of the five worst declining areas with a rate of -14.0%.

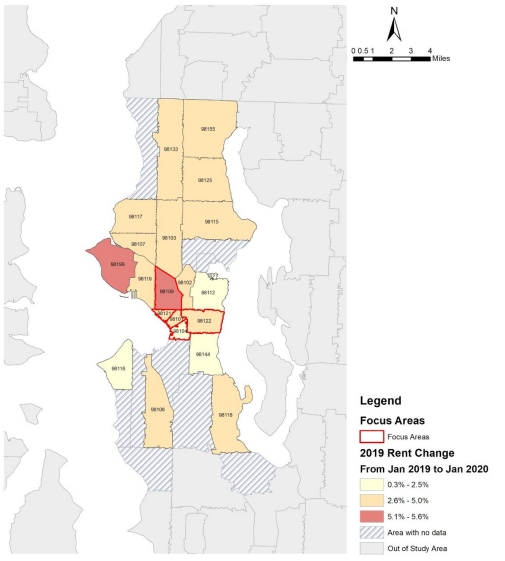

Figure 2 Rent change over the year 2019

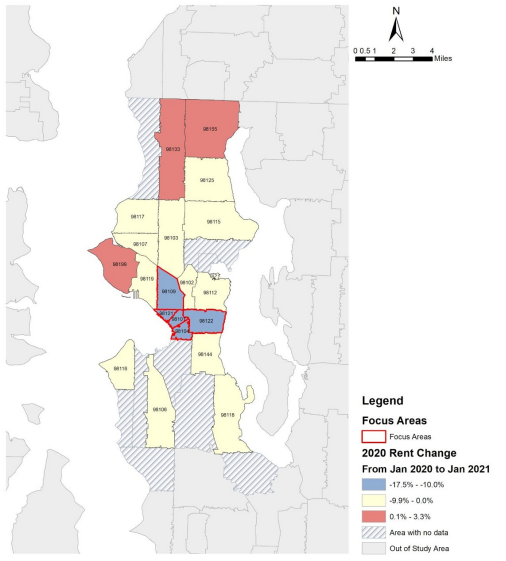

Figure 3 Rent change over the year 2020

Looking at rent levels in 2020 January and 2021 January, rents in the focus areas seem to have fallen faster than in the surrounding areas (Fig. 4 and 5). The rents in Seattle were divided into 3 classes from High Rent to Low Rent. The High Rent class includes areas with the top 3 highest rents and the Low Rent class includes areas with the top 5 lowest rents. Before the pandemic, downtown Seattle was achieving consistently the highest rent. In 2021, however, only 98101 and 98121 kept in the first class with the highest rents. Most surrounding areas were downgraded by one class. 98122 in the 5 focus areas even downgraded to the Low Rent class. Among the 3 High Rent areas in early 2021, 98101 still held the highest rent of $2308 while 98199 in the northwest became the second with a rent of $2144. For the Low Rent areas, 98118 in the south-east upgraded to the Medium Rent class instead of the 2 Low Rent areas close to Downtown Seattle previously. As a preliminary

conclusion for the classification of the three rent levels, the difference in rents at the geographic level has become more balanced under the influence of the pandemic. Although the city center is still the area with the highest rents, rents in areas far from the city center have seen more growth. High-rent areas are spreading from the city center to the surrounding areas.

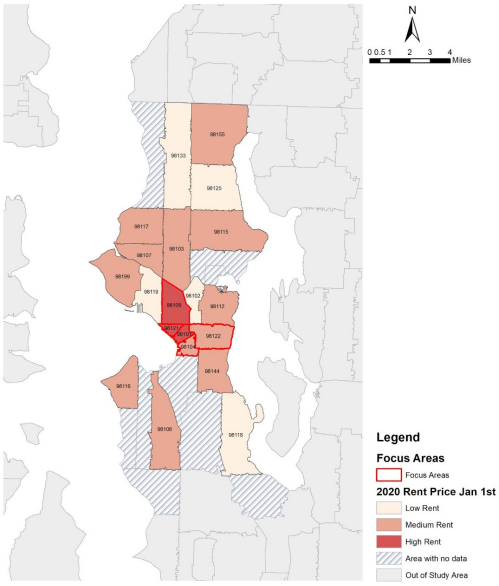

Figure 4 Rent Level in January 2020

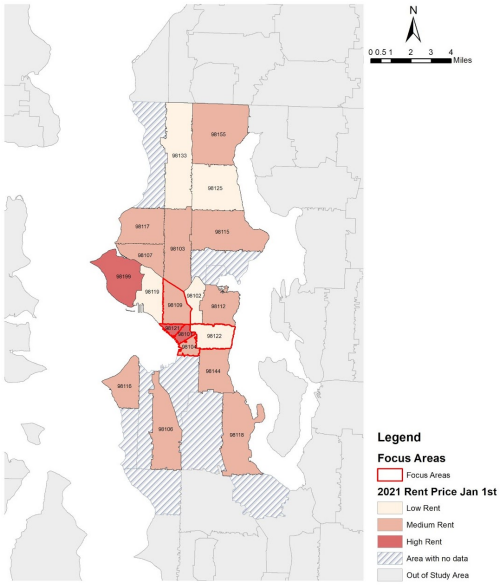

Figure 5 Rent Level in January 2021

Looking into the COVID-19 data at the zip code level, as shown in Figure 6 and Figure 7, we can see that the focus areas including Downtown Seattle were not the areas with the most positive cases despite its high population density. Both the positive cases and the positivity rate show a decreasing pattern when approaching the center of the city. Areas in the north and south of the city have more positive cases and higher positivity rates. It can be explained

by a trend of moving out that is a vector of the spread of the disease. Though the city center has a high population density, there are smaller households. People's destinations in suburban areas are more likely socially connected areas, sheltering with friends and family that may cause a high infection rate (Coven et al. 2020). Especially, 98118, a residential area in the south-east, has both the highest positive rate of 57.2 per 1,000 residents and the most positive cases of 2,807. Being one of the moving destinations can be one of the reasons for the high severity of the pandemic.

Comparing the COVID-19 data with the rental market data in GIS, we see that the decreasing rate of rent pattern is almost the opposite of the COVID-19 pattern. We find that the rate of rent decline is not directly related to the severity of the pandemic at the zip code level. In other words, this change in rents and the moving trend do not come from the fear of the pandemic in a specific area. Socioeconomic factors may play a more important role than the pandemic. Coven et al. (2021) suggest a causal association of migration and subsequent case growth with a supporting fact that urban residents fled to socially connected areas, consistent with the notion that individuals were sheltering with friends and family or in second homes. The patterns indicate that people are moving from areas where the pandemic was milder (city center) to more severe (less dense areas). The rent, therefore, declined sharply in the city center. Other socioeconomic factors like high-tech employees and the working-age population, as the major customers of the rental housing market, may also contribute to the rent decline under the impact of the pandemic. Those people have the capacity to work from home and are more inclined to move away from the city center. So, the higher the proportion of these people, the greater the secondary impact of the pandemic, and so that the more rents will fall.

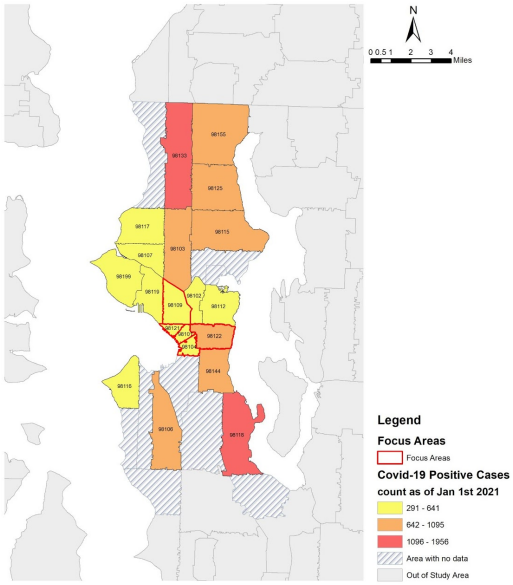

Figure 6 COVID-19 Positive Cases as of Jan 1st, 2021

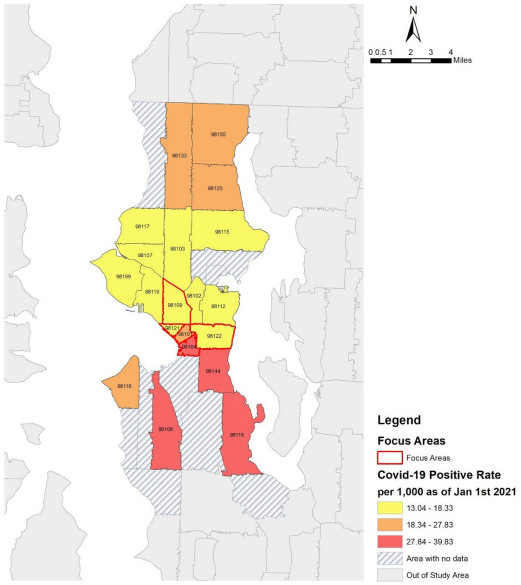

Figure 7 COVID-19 Positive Rate per 1,000 residents as of Jan 1st, 2021

From the housing supply side, we use the number of new housing permits and completed units as the indicator of future housing supply (Fig. 8 and 9). These supply indicators show fewer permits issued and completed closer to the city center. Among the five focus zip code areas, 98104 shows a different trend with 931 permit units issued and a 7% increasing rate while the other four areas show the greatest decline in the city. The reason for the difference may be the worse housing conditions in that area. Zip code 98155 is a special area that had 0 permits issued and 0 completed in the northeast corner of Seattle. In this research, it can be regarded as an outlier in a special period of the pandemic.

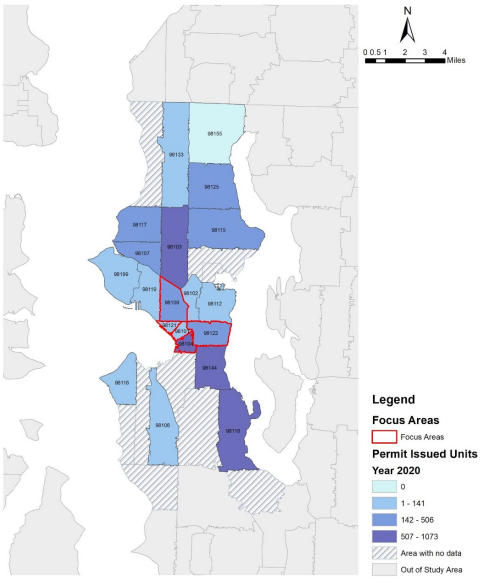

Figure 8 New Housing Units Permit Issued in 2020

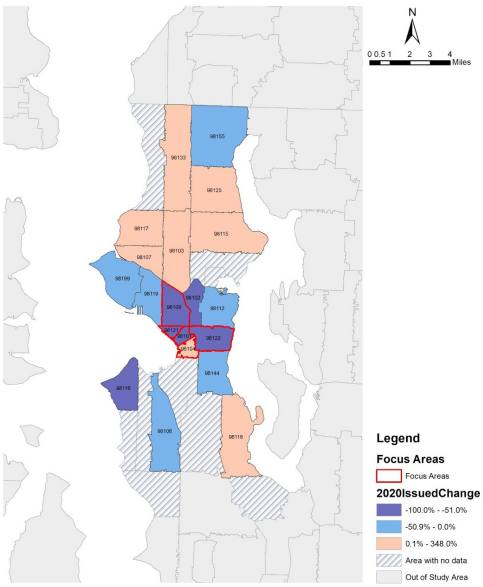

Figure 9 New Housing Units Permit Issued change over 2020

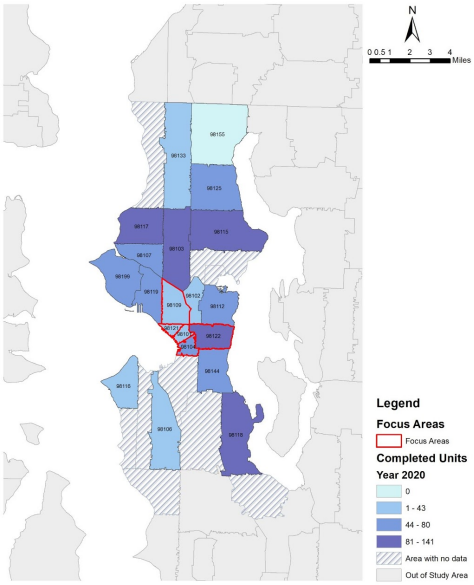

Figure 10 New Housing Units Completed in 2020

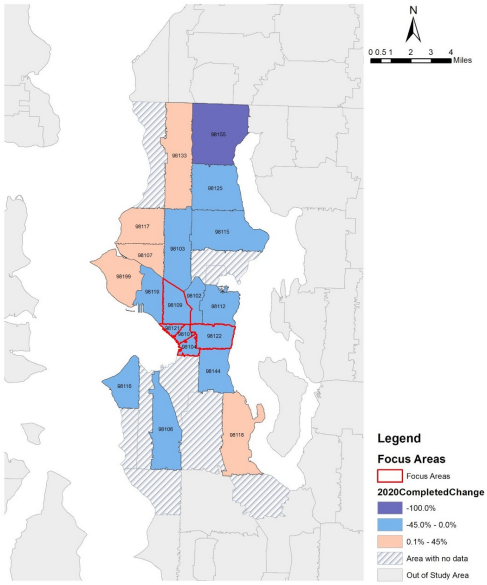

Figure 11 New Housing Units Completed Change over 2020

The pandemic can be one reason for the distribution of supply in Seattle but after more than a decade of significant infill development, the limited space in the city center also contributes to fewer permits of new development. So, even though the number of permits issued and completed in the city center is greatly reduced, the pandemic is not the leading cause for the reduction in supply and the further decline in rents.

The population density pattern of the different zip codes within the city of Seattle from 2019 data (Fig. 12) highlights the concentrated population density in some downtown core zip codes. 98121 has the highest density of 79.2 people per acre.

The percentage of renter-occupied units is another indicator that can help explain the

different rent changes between the focus areas and the others. The focus areas in the core of the city have the highest density of renter units. (Fig. 13) That means the focus areas have a more sensitive rental housing market to the potential shock. That can be an even stronger explanation than the population to the greater decline in the city center than suburban areas. The tenure pattern is similar to the rent change rate 2020 with a concentration on the city center. This means that areas with a higher proportion of renter-occupied units may have relatively greater changes in rents affected by the pandemic. Renters' demand is an important factor in rent changes. The high proportion of renter-occupied units over 60% means more renters than house owners. The tenure pattern in Seattle is more suitable for renters than homeowners with a high price-to-rent ratio according to the Rent vs. Buy Index pattern from Zhai & Peng (2021). Under the same conditions, the more renters, the more serious the rent will be affected by external changes, which can explain the sharp decline in rents in the city center with similar renter-occupied units rate. The significant rent decline happening in the focus areas indicates a great change in the renters' demand for living there. The attractiveness loss of the city center and the work from home policy are the possible factors that affect most renters' decision of living in a place and encourage them to leave.

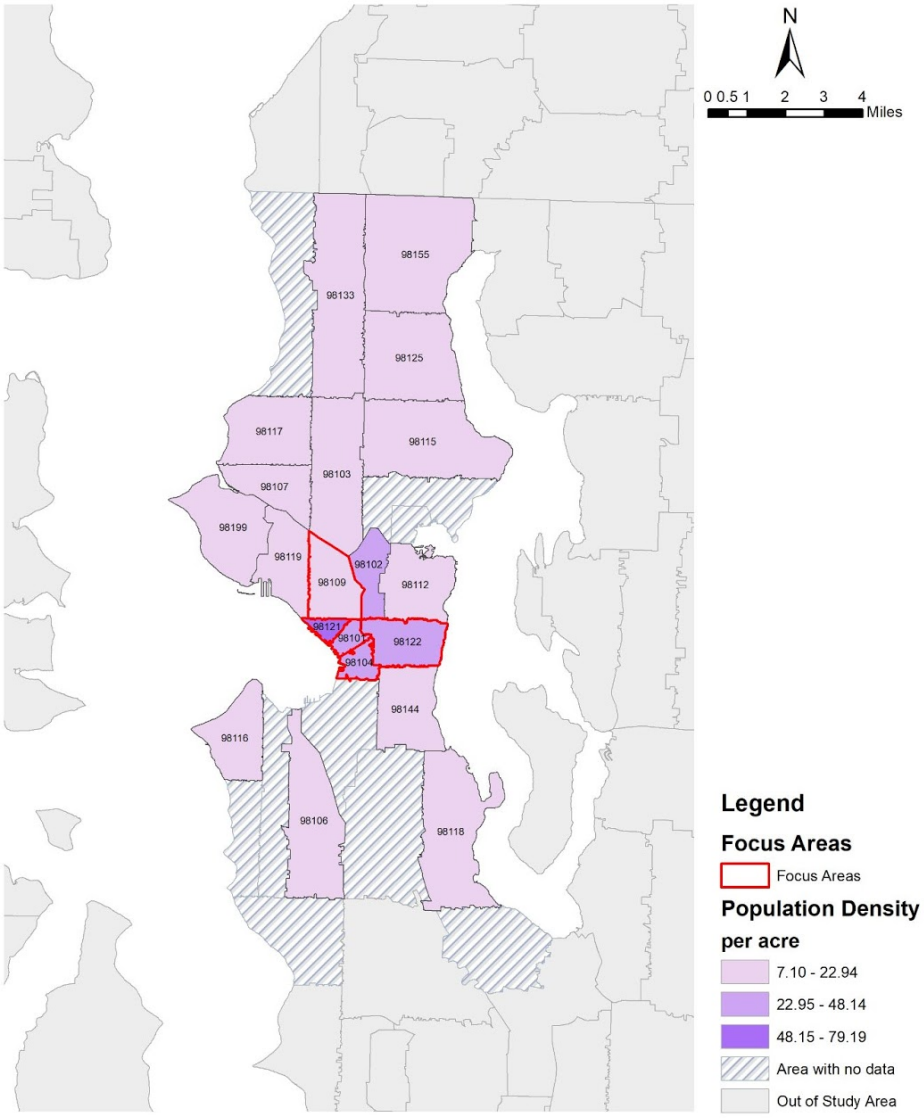

Figure 12 Population Density per acre 2019

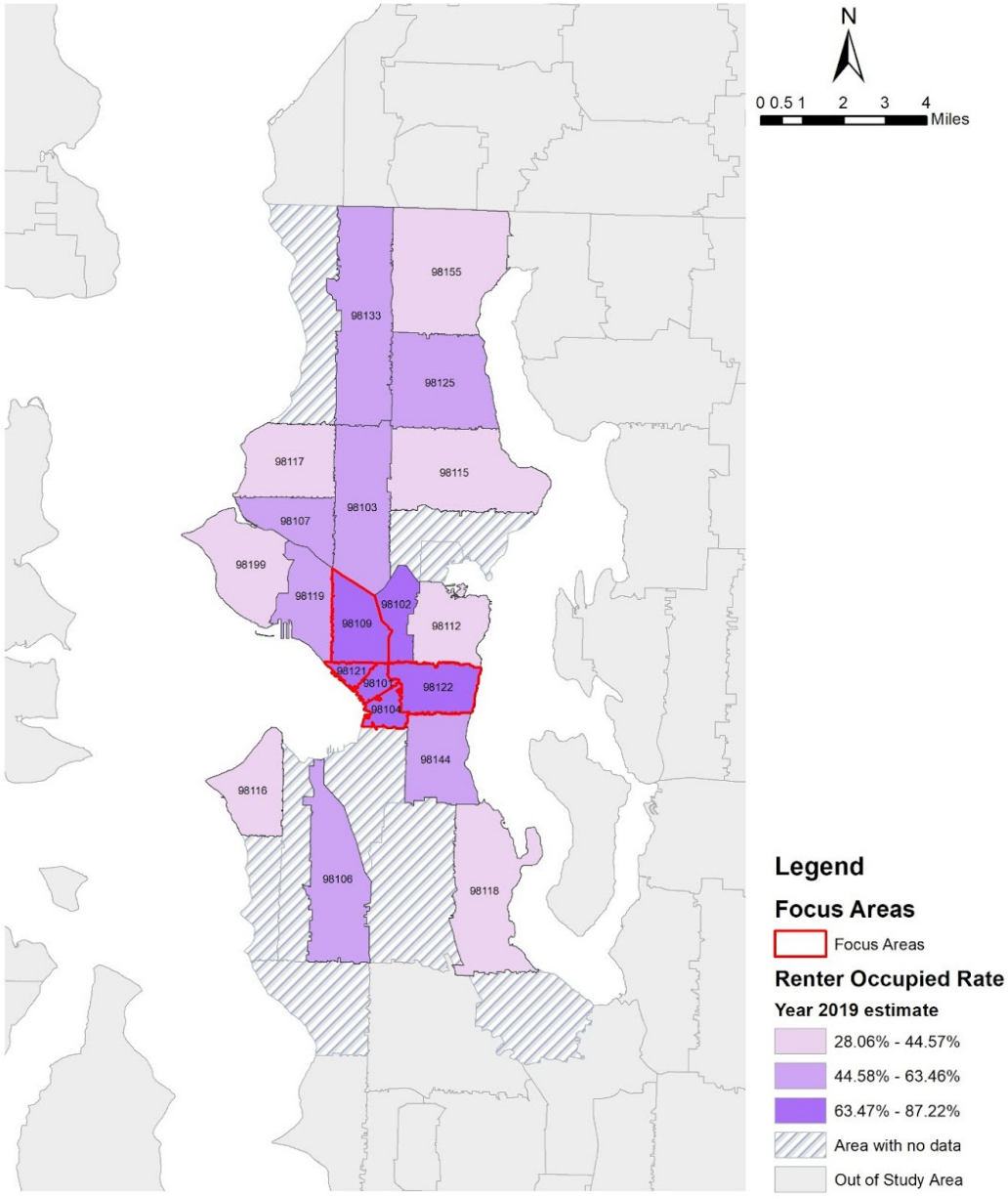

Figure 13 Renter Occupied Units Rate

4.2 Comprehensive Analysis

By comparing the spatial distribution of rent change over 2021 with COVID-19 cases and positivity rate (Fig. 4-5 and 6-7), we see a divergence between areas with rent decline compared to those being affected more by the pandemic. The pattern of COVID-19 positive cases and positivity rate can be interpreted as an increasing trend from the city center to the periphery with the least cases in the focus areas that have the greatest rent decline rate. Before 2020 the rent in Seattle still grew at a healthy rate and kept at the high-rent level. Problems like crime and homelessness have been increasing exponentially within certain areas of the focus area during COVID making the downtown less attractive.

Table 1 Information Table for the Focus Areas and Seattle (the whole study area)

	98121	**98104**	**98101**	**98109**	**98122**	**Seattle**
Neighborhoods	Belltown, Denny Triangle	Pioneer Square, International District, First Hill	Central Business District, First Hill	East Queen Anne, Westlake, South Lake Union, Uptown	Pike/Pine, The Central District	
Rent Jan 2021 ($)	$ 2,113	$ 1,802	$ 2,308	$ 1,907	$ 1,732	$ 1,915
Rent Change 2019	4.66%	2.46%	4.71%	5.22%	3.77%	3.45%
Rent Change 2020	-17.53%	-15.12%	-14.17%	-13.98%	-11.41%	-6.49%
Positive Cases	385	641	374	638	812	20,348

Positive Rate (per 1,000)	17.28	34.95	23.02	18.26	18.33	30.53
Population	22,274	18,339	16,247	34,939	44,306	666,553
Population Density (per acre)	79.2	37.9	48.1	22.9	29.9	14.17
Area (acre)	281	484	337	1,523	1,482	47,038
Units Permitted 2020	112	931	6	223	495	6,697
Permit Change 2020	-75.3%	6.5%	-99.7%	-78.3%	-51.5%	-29.6%
Units Completed 2020	38	52	40	35	87	1,212
Completed Change 2020	-15.6%	-14.8%	-32.2%	-28.6%	-6.5%	-9.6%
Renter Occupied Rate	77.1%	87.2%	82.6%	75.9%	67.5%	54.32%
Age 18-34 percentage	48.9%	38.6%	40.6%	52.8%	48.7%	32.7%

In-depth Analysis of Individual Zip Code

98101 is known as the Central Business District of Seattle. It's densely populated with 48.14 people per acre. Commercial, retail, and tourism are the main businesses in this area. There are various retail stores, shopping malls, and restaurants. The famous Pike Place Market and Seattle Aquarium are located here. This is a very active place, with a significant flow of people and traffic, and employment opportunities. The average rent price in January 2020

was $2689 which dropped by 14.17% in 2020, decreasing further to $2308 in January 2021. The rent was the highest among the study areas and kept first place in 2021 despite the decline. It's easy to understand that the rental price here has dropped drastically due to fear of COVID. The flow of people in Pike Place market presented an increased risk of infection. Being close to this famous attraction was an advantage, but it became a disadvantage because of the pandemic closures of office buildings and the WA governor's restrictions to restaurants. Moreover, under the influence of self-quarantine and social distance recommendations, the externalities of neighborhoods with adequate services and entertainment facilities were no longer available. With the work from home policies, the value from low commuting cost for living here was also worthless. Therefore, more people, whether working here or high-income, chose to leave to find lower-rent and lower-density neighborhoods.

98104 contains Pioneer Square and the International District. The government center is located there with Seattle City Hall, King County District Court, and other agencies. Protests and riots have always been big problems here. The average rent price here in January 2020 was $2123 which dropped by 15.12% in 2020 and decreased further to $1802 in January 2021. The rent used to be the fourth highest in Seattle, but one year after the outbreak of the pandemic, the rent is now even lower than the average rent of $1915 among the study areas. The decline rate is the second-highest. Different from the reasons for other areas, the significant increase of the homeless population in tents, the more serious protests and riots played an even more important role in the neighborhood. With such high danger and high possibility of infection, the demand for the area has decreased, even for government workers who work here. The positive rate of 47.1 per 1,000 residents here is the

third-highest among the study areas. However, the permits in this zip code are higher than other zip codes as the structures are old and it has been a practice to demolish rather than seismically retrofit buildings. 931 new unit permits were issued in 2020 while most areas decreased their new permits. So the hyper-supply situation here is stronger than in any other place.

98109 is a mixed area with both high-density commercial areas and low-density residential neighborhoods. It's also a densely populated upscale area. It contains Uptown with Seattle Center, South Lake Union with high-tech companies, and East Queen Anne as a low-density single-family residential area. The average rent price in January 2020 was $2217 which dropped by 14.0% and decreased further to $1907 in January 2021. The rent was the third-highest in Seattle and it also had the second-highest increasing rate of 5.2% in the year 2019. But in 2020, rent was even lower than the average rent in Seattle declining by more than 10%. The pandemic brought a shock to the rental market here. Most renters here are high-income and work for local high-tech companies such as Amazon, Google, and others. The majority of employment is computer and science. With the policy of work from home, they don't need to live here for the reduction in commuting costs by paying the high rent. So many renters left this area and therefore the rent went down.

98121 is known as Belltown or Denny Triangle. It has a concentration of Amazon, Google, and high-tech company buildings. These companies provide the area with a large scale high-income worker population and housing demand. But this area became the one facing the greatest shock in 2020 due to the pandemic. The average rent price in January 2020 was $2562 which dropped by 17.5% and decreased further to $2113 in January 2021. Holding

the greatest rent decreasing rate of 17.53%, this area has been most severely affected by the pandemic. And it's the area with the least permits among the five focus areas both in 2019 and 2020 and no completed units in 2021. This area has been developed intensively and there are limited vacant lots. So the low supply and fewer permits are reasonable. Located to the right downtown area of Seattle, commercial and business are the major function while residential use is less than other areas. Usually, the living space per person is lower in the center of the city, and population density is high in apartments, especially in the central area with extremely high rent. Those people who work here prefer to pay a higher rent premium to avoid the financial and physical commute cost. When most retail stores and restaurants closed and work from home, living in this area became more challenging. As people were working from home, some needed more space which could not easily be found in the area. From the significant rent decline, we see the problems of living in the central area where expanding one's unit size is not that easy.

98122 is an area dominated by low-density housing. The Central District is the major neighborhood here. The average rent price in January 2020 was $ 1955 which dropped by 11.41% and reached $1732 in January 2021. After the outbreak of COVID-19, the rent became the second-lowest among the study areas. As a neighborhood close to the city center, the average rent price is not high. But the decreasing rate here was still over 10%. That means the neighborhood lost its attraction to the renters. The potential problem here might be the most positive cases of 1155 among the five focus areas.

4.3 Statistical Analysis

The thesis's second research question asks: ***What are some of the factors associated with the decline in rent over the last year in Seattle?***

From the different rent change rates in different locations, we can estimate a higher decline in the higher-rent areas and a lower decline or increase in the lower-rent areas. By ranking the rents of all the 20 study areas at the beginning of 2019, 2020, and 2021, the curve shows an obvious flattening trend after the year 2020 (Fig. 14). As Zhai & Peng (2021) found that, home prices and rents in the U.S. have been growing steadily over the past decade. In Seattle, rent trends also showed the same trend before 2020. The overall rental prices at the beginning of 2020 have increased compared to one year ago. However, the higher end of the rent ranking gradient at the beginning of 2021 has dropped significantly from 2020, but the lower-rent end didn't drop much. That means the overall rent prices in the city of Seattle are becoming less dispersed while declining amid the COVID-19 pandemic and the higher-rent areas are affected more severely than lower-rent areas. Table 2 shows the rent ranking for all the zip codes in the three years with the focused areas highlighted. Changes in the ranking indicate the different extent of the impact of COVID-19 in each zip code area. Four of the focus zip codes used to have the highest rents among the study areas in 2019 and 2020, but at the beginning of 2021 their rankings began to scatter significantly with their greatest rent decline. 98101 has maintained the highest rent in the city, but with a high rate of decline, the highest rent in the city has also fallen. 98109 and 98104 even fell to tenth and fourteenth. In contrast, the rankings of the bottom five areas are relatively stable. 98125, holding the lowest rent in the study area for 2020 and 2021, has very close increase rate

over 2019 and decline rate over 2020 which prevent the lower end of the rent ranking gradient from dropping much.

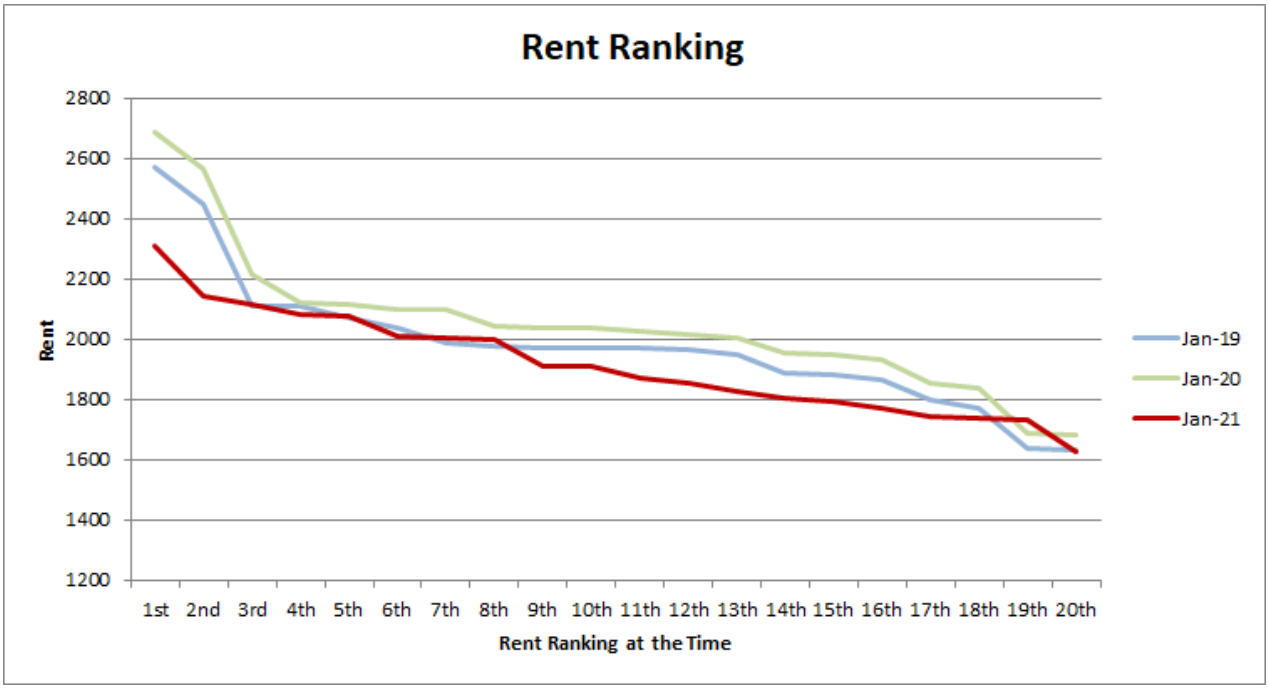

Figure 14 Rent Ranking

Table 2 Rent Ranking for the year 2018, 2019, and 2020

(the 5 focus areas are marked in color)

Rank	2019	2020	2021
1st	**98101**	**98101**	**98101**
2nd	**98121**	**98121**	98199
3rd	98112	**98109**	**98121**
4th	**98109**	**98104**	98155
5th	**98104**	98112	98117
6th	98117	98199	98144
7th	98199	98117	98112
8th	98155	98106	98115

9th	98144	98155	98107
10th	98106	98115	98109
11th	98115	98107	98103
12th	98116	98144	98106
13th	98107	98116	98116
14th	98103	98122	98104
15th	98122	98103	98118
16th	98102	98102	98102
17th	98119	98119	98119
18th	98118	98118	98133
19th	98125	98133	98122
20th	98133	98125	98125

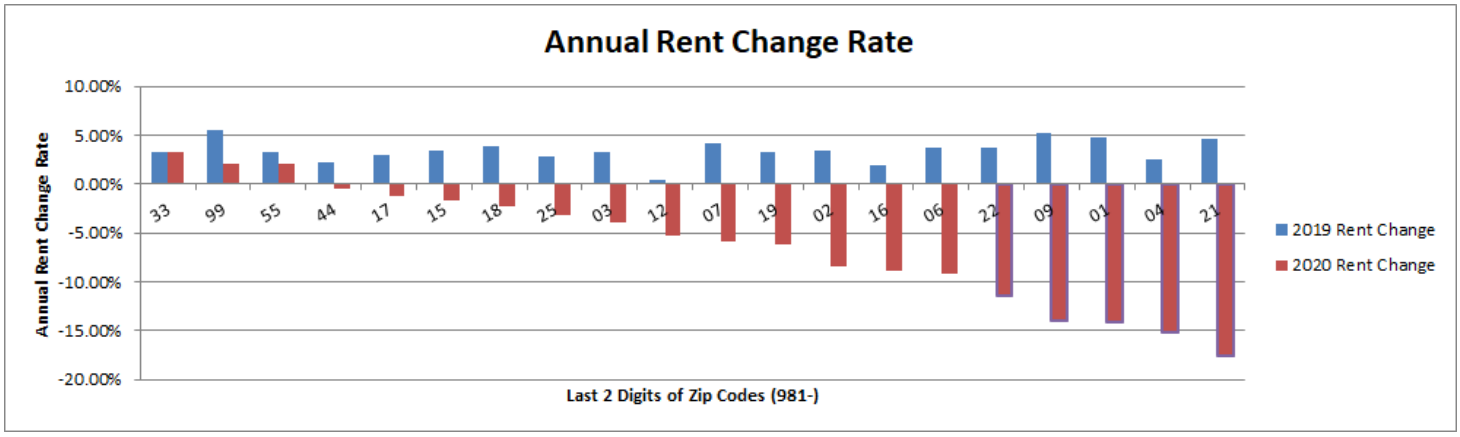

Figure 15 Annual Rent Change Rate for the 20 zip codes

The rent growth rates over 2019 for all areas are positive around 3% and the highest rates are around 5%. The 2020 annual rent change for most zip codes became negative. Almost

half of the zip codes have rent decline over 5%. The five focus zip codes declined with rates even over 10%. From the overall rent change rate gradient over 2020 for all zip codes ordered by 2020 rent change shown in Fig. 15, the decreasing rate varies greatly among zip areas. The highest rent change is 3.26% in 98133 and the lowest rent change is -17.53% in 98121. There is a huge gap in the rent change rate between zip codes which indicates the uneven impacts of the pandemic on spatial location.

The correlation analysis shows that the rent change rate in 2020 has significant correlations at the 0.01 level to population density, tenure (rate of renter-occupied units), teenage group population under 17, working-age group population between 18 to 34 , and high-tech employees (computer, engineering, and science). And it also has relatively significant correlations at the 0.05 level to the permit issued change rate, population, age group between 35 to 59, and employees in sales and natural resource related careers. Those factors are proved to be associated with the rent decline in the city of Seattle during the COVID-19 pandemic. Population density, rate of renter-occupied units, age group between 18-34, and proportion of high-tech employees are the 4 most critical factors that are negatively correlated with the degree of rent change rate in the area. These 4 factors are potential explanations for why rents in the specific area are so severely affected by the pandemic. Areas that are high in those factors have a higher possibility to see a great decline in rents. On the other hand, the teenage group under 17 has a strong positive correlation with the rent change rate.

The rent change rate over 2020 shows significant correlations to population density and rate of renter-occupied units at the 0.01 level and a relatively significant correlation with the

population at the 0.05 level. The rent change and both population density and renter occupancy rate are negatively correlated with r values of -0.77 and -0.81. Both |r| values are over 0.7 which means the two variables are strongly correlated to the rent change.

There are two strong correlations between the age of residents and the rent change rate amid the pandemic. A strong positive correlation between the teenage group under 17 to the rent change with r value of 0.81 and a strong negative correlation between the working-age group 18-34 to the rent change with r value of -0.73. That means rent in the areas with more teenagers are more likely to be stable. And in those areas with a more working-age population, rents are more likely to decrease more under the impact of the pandemic. We can estimate that areas with higher population density or higher renter occupancy rates are more likely to face a greater decline in rent price over the year 2020.

Percentage of employment in Computer, Engineering and Science has a relatively strong negative correlation with the rent change rate. The r value is -0.63, significant at the 0.01 level. Areas with more employees in these high-tech sectors may have higher possibility to see sharper rent decline. The focus areas in the city center are the areas having a high proportion of those high-tech employees. That can be one of reasons for why those areas close to downtown saw the greatest rent decline.

From the correlation analysis, we find that the rent change rate has no significant relationship with the COVID-19 cases or positive rate (Appendix. Pearson Correlations, All Variables). That means the rent changes at zip code level are affected by the secondary impact of the COVID-19 pandemic rather than the pandemic itself. This finding is different

from the finding of Kuk et al. (2021) that heterogeneity in COVID-19 case rates helps explain differential rental market trends at the metropolitan area level and indicates less direct impact of COVID-19 on the rental housing market at the neighborhood level. Instead, the COVID-19 positive cases and population also have a significant correlation at the 0.01 level. They have a relatively strong positive correlation with an r value of 0.65. (Appendix. Pearson Correlations, All Variables). The correlation between the number of COVID-19 positive cases and the population cannot explain the great decline in rent observed downtown with high population density but not necessarily a large population.

For permit issued change rate, the |r| value equals 0.513, between 0.4 - 0.6, which means that these two variables are moderately correlated (Table 3). That means the great change in 2020 caused by the COVID-19 pandemic can be partly explained by the supply change. This is a reasonable result based on the microeconomic theories. The rent change rate has a positive correlation to the permit change rate. Developers often use market rent signals as an indicator of demand. If the rent in a place has increased significantly, developers will tend to get more development permits there, and vice versa.

The correlation analysis answers the research question of what are the factors associated with the decline in rent over 2020. The research suggests that there is no direct correlation between the rent change and COVID-19 cases or positive rate at zip code level in the city of Seattle. Those zip codes have high population density, high-tech employment, working-age population (18-34), and renter-occupied units rates are more likely to have greater decline in rents. These factors make the areas vulnerable to the secondary impact of the pandemic such as work from home policy, the subsequent migration of residents, and the decline in

the attractiveness of the city center and further affect the rents. In addition to the four major factors that positively correlated to rent decline, the teenage population (under 17) has a strong positive correlation with the rent increase. And there are also factors that show relatively high correlation to the rent change over 2020. In summary, the extent to which rents in Seattle are affected by the COVID-19 pandemic is the result of the combined effects of multiple factors of different spatial locations at the zip code level.

Correlations

		RentChange20	IssuedChange	PopulationDensity	Population	Tenure	Ageunder17	Age18to34	Age35to59	Computer	Sales	Natural
RentChange20	Pearson Correlation	1	.513*	-.768**	.484*	-.812**	.813**	-.729**	.524*	-.635**	.457*	.539*
	Sig. (2-tailed)		.021	.000	.031	.000	.000	.000	.018	.003	.043	.014
	N	20	20	20	20	20	20	20	20	20	20	20
IssuedChange	Pearson Correlation	.513*	1	-.372	.506*	-.310	.378	-.369	.099	-.375	.375	.279
	Sig. (2-tailed)	.021		.106	.023	.183	.100	.110	.678	.103	.103	.233
	N	20	20	20	20	20	20	20	20	20	20	20
PopulationDensity	Pearson Correlation	-.768**	-.372	1	-.398	.724**	-.818**	.634**	-.323	.703**	-.404	-.550*
	Sig. (2-tailed)	.000	.106		.082	.000	.000	.003	.164	.001	.078	.012
	N	20	20	20	20	20	20	20	20	20	20	20
Population	Pearson Correlation	.484*	.506*	-.398	1	-.383	.450*	-.151	-.169	-.269	.106	.280
	Sig. (2-tailed)	.031	.023	.082		.096	.046	.526	.475	.251	.656	.232
	N	20	20	20	20	20	20	20	20	20	20	20
Tenure	Pearson Correlation	-.812**	-.310	.724**	-.383	1	-.954**	.853**	-.685**	.597**	-.320	-.601**
	Sig. (2-tailed)	.000	.183	.000	.096		.000	.000	.001	.005	.170	.005
	N	20	20	20	20	20	20	20	20	20	20	20
Ageunder17	Pearson Correlation	.813**	.378	-.818**	.450*	-.954**	1	-.830**	.577**	-.712**	.417	.700**
	Sig. (2-tailed)	.000	.100	.000	.046	.000		.000	.008	.000	.067	.001
	N	20	20	20	20	20	20	20	20	20	20	20
Age18to34	Pearson Correlation	-.729**	-.369	.634**	-.151	.853**	-.830**	1	-.828**	.708**	-.367	-.672**
	Sig. (2-tailed)	.000	.110	.003	.526	.000	.000		.000	.000	.112	.001
	N	20	20	20	20	20	20	20	20	20	20	20
Age35to59	Pearson Correlation	.524*	.099	-.323	-.169	-.685**	.577**	-.828**	1	-.457*	.207	.414
	Sig. (2-tailed)	.018	.678	.164	.475	.001	.008	.000		.043	.382	.070
	N	20	20	20	20	20	20	20	20	20	20	20
Computer	Pearson Correlation	-.635**	-.375	.703**	-.269	.597**	-.712**	.708**	-.457*	1	-.553*	-.862**
	Sig. (2-tailed)	.003	.103	.001	.251	.005	.000	.000	.043		.011	.000
	N	20	20	20	20	20	20	20	20	20	20	20
Sales	Pearson Correlation	.457*	.375	-.404	.106	-.320	.417	-.367	.207	-.553*	1	.539*
	Sig. (2-tailed)	.043	.103	.078	.656	.170	.067	.112	.382	.011		.014
	N	20	20	20	20	20	20	20	20	20	20	20
Natural	Pearson Correlation	.539*	.279	-.550*	.280	-.601**	.700**	-.672**	.414	-.862**	.539*	1
	Sig. (2-tailed)	.014	.233	.012	.232	.005	.001	.001	.070	.000	.014	
	N	20	20	20	20	20	20	20	20	20	20	20

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3 Pearson Correlations, Significant Correlations

Through T-Test, the research tries to explore if there is a significant difference between the

focus areas and other study areas. 20 areas are divided into 2 groups: the focus areas and other areas. The result suggests the rent change rate over 2020 has a significant difference between the focus areas and other areas with the p value of 0.000. That means the five focus zip codes were obviously more severely affected by the COVID-19 pandemic than other areas. The p value of population density is 0.038 and the renter occupancy rate is 0.000. (Table 4) Both population density and renter occupancy have significant differences between the focus areas and other areas. So these two variables are part of possible reasons for the greater decline happening in those focus areas. It's possible that the focus areas in the city center with higher population density tend to have higher rates of renters because of the demand for higher density neighborhoods before the pandemic and therefore rents there declined most after the breakout of the pandemic when that demand started to decrease.

For all types of occupation shown in Table 5, two sectors have significant differences between the focus areas and the others: Computer, engineering and science, and Natural resources, construction, and maintenance (have p value under 0.01). The different proportion of those employment are also the possible reasons for different levels of impact by the pandemic. Employees in computer, engineering and science are more capable of telecommuting and leaving the city center. It's the opposite for those working in natural resources, construction, and maintenance considering their positive correlation with the rent change rate.

For the age groups, the population structure in the focus areas and other areas are significantly different. The two groups, age under 17, and between 18 to 34, show significant

differences with p value under 0.01. The early working-age population between 18 to 34 are more likely to be renting and have a demand for being close to the city center while families with children under 17 usually own a house with more space and better environment away from the city center. And on the other hand, the population between 18 to 34 can make decisions to move by themselves while younger people cannot. So areas with more people between 18-34 are more likely to see higher rent decline and areas with more teenagers may probably see a relatively stable rent.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
RentChange20	Equal variances assumed	3.025	.099	-5.835	18	.000	-.1116067	.0191286	-.1517944	-.0714190
	Equal variances not assumed			-7.781	13.188	.000	-.1116067	.0143428	-.1425477	-.0806656
RentChange19	Equal variances assumed	.062	.806	1.721	18	.102	.0099867	.0058014	-.0022017	.0221750
	Equal variances not assumed			1.761	7.165	.121	.0099867	.0056712	-.0033613	.0233346
Rent	Equal variances assumed	2.331	.144	.849	18	.407	75.93333	89.44081	-111.97483	263.84150
	Equal variances not assumed			.674	5.125	.529	75.93333	112.61477	-211.44188	363.30855
PopulationDensity	Equal variances assumed	13.196	.002	5.156	18	.000	29.95200	5.80918	17.74736	42.15664
	Equal variances not assumed			3.020	4.136	.038	29.95200	9.91768	2.76967	57.13433
Population	Equal variances assumed	.016	.901	-1.376	18	.186	-8142.20000	5917.76088	-20574.95427	4290.55427
	Equal variances not assumed			-1.334	6.555	.227	-8142.20000	6105.72578	-22780.83023	6496.43023
Tenure	Equal variances assumed	2.031	.171	5.188	18	.000	.3028400	.0583788	.1801907	.4254893
	Equal variances not assumed			6.609	11.665	.000	.3028400	.0458221	.2026829	.4029971

Table 4 Independent-samples Test 1, Socioeconomic, Grouped by Focus Areas and Other Areas

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Business	Equal variances assumed	.433	.519	1.222	18	.238	.0283200	.0231767	-.0203725	.0770125
	Equal variances not assumed			1.109	5.965	.310	.0283200	.0255430	-.0342713	.0909113
Computer	Equal variances assumed	1.070	.315	3.770	18	.001	.0843933	.0223840	.0373662	.1314204
	Equal variances not assumed			3.231	5.556	.020	.0843933	.0261230	.0192133	.1495733
Education	Equal variances assumed	.036	.852	-1.830	18	.084	-.0269533	.0147279	-.0578956	.0039889
	Equal variances not assumed			-1.562	5.531	.173	-.0269533	.0172558	-.0700608	.0161541
Health	Equal variances assumed	.082	.778	-.679	18	.506	-.0052200	.0076848	-.0213652	.0109252
	Equal variances not assumed			-.774	8.865	.459	-.0052200	.0067462	-.0205166	.0100766
Sales	Equal variances assumed	2.610	.124	-2.409	18	.027	-.0188733	.0078357	-.0353356	-.0024111
	Equal variances not assumed			-3.709	17.828	.002	-.0188733	.0050891	-.0295726	-.0081741
Natural	Equal variances assumed	6.800	.018	-2.990	18	.008	-.0252867	.0084583	-.0430570	-.0075164
	Equal variances not assumed			-4.985	16.922	.000	-.0252867	.0050721	-.0359915	-.0145818
Production	Equal variances assumed	1.065	.316	-.940	18	.360	-.0145467	.0154803	-.0470695	.0179762
	Equal variances not assumed			-1.056	8.605	.320	-.0145467	.0137755	-.0459284	.0168351

Table 5 Independent-samples Test 2, Occupation Percentage, Grouped by Focus Areas and Other Areas

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
RentChange20	Equal variances assumed	3.025	.099	5.835	18	.000	.1116067	.0191286	.0714190	.1517944
	Equal variances not assumed			7.781	13.188	.000	.1116067	.0143428	.0806656	.1425477
Ageunder17	Equal variances assumed	.018	.896	5.274	18	.000	.1066333	.0202182	.0641566	.1491101
	Equal variances not assumed			5.496	7.406	.001	.1066333	.0194015	.0612609	.1520058
Age18to34	Equal variances assumed	.502	.488	-3.697	18	.002	-.1620067	.0438180	-.2540648	-.0699486
	Equal variances not assumed			-4.537	10.583	.001	-.1620067	.0357065	-.2409754	-.0830379
Age35to59	Equal variances assumed	.366	.553	2.828	18	.011	.0457133	.0161649	.0117521	.0796746
	Equal variances not assumed			2.596	6.058	.041	.0457133	.0176099	.0027236	.0887031
Ageover60	Equal variances assumed	3.076	.096	.420	18	.680	.0096733	.0230566	-.0387668	.0581134
	Equal variances not assumed			.333	5.118	.753	.0096733	.0290698	-.0645367	.0838834

Table 6 Independent-samples Test 3, Age groups, Grouped by Focus Areas and Other Areas

Through the basic statistical analysis, we figure out the 5 major factors that are associated with rent change during the pandemic. They are population density, tenure (rate of renter-occupied units), teenage group population under 17, working-age group population between 18 to 34 , and high-tech employees (computer, engineering, and science). Those factors also contribute to the different conditions in the focus areas with the greatest rent decline rate. We found that the high population density, high rate of renter-occupied units, larger working-age group population and more high-tech employees probably made rents in the areas decrease more during the pandemic to some extent.

4.4 Summarizing in a Story

The significant rent decrease indicates a decrease in demand for higher rent properties in the center of the city, which can have long lasting impacts if workers do not return to their in-person office space as expected in the following months. The remote working policy which started in March 2020 and made a large portion of urban employees able to work from home and reduce their avoidance for transportation and commuting costs is creating more issues for the rental market in the downtown. Therefore the demand for living in the center of the city also declined. This policy has a very obvious influence on people's living choices in location and to the market rent prices. The impact of the policy changes is stronger as it is closer to the city center. However, people's capacity to leave matters. Because the working-age population (18-34) and high-tech employees are the groups that have the strongest capacity to work from home and they are more likely to do so. Renters are also the population that have high mobility in choice of living place. Younger renters working in tech are significantly more represented in Seattle's downtown than in other

areas. So the impact of the pandemic in downtown Seattle is greater and associated with a significant decline in rents. High-tech employees, including computer, engineering, and science, account for 23% of employment in the 5 focus areas (city center) while only 15% in other areas. These people are probably also at the early working-age and rent in the city center. They are the major population that has a high work-from-home capacity and choose to leave the city center. Also, working from home requires separate spaces for work making small apartments, which is the norm downtown more difficult to work from. Living in a place away from the center with lower rent and bigger spaces seemed to be attractive for a certain market segment. In a work-from-home world, people need more home space, more safety, and they might reevaluate their home location.

After the quarantine and work from home, policies took effect and when people took it more seriously, traffic declined and the cost of commuting decreased. The attraction of lower commuting costs does not seem to balance the high rent downtown as long as people work from home. The decline in attractiveness of the city center, the reduction in retail, activities, and restaurant services, as well as the worsening social environment in the city center such as homelessness, protests, riots, and crime, have combined to reduce the attractiveness of the city center during the COVID-19 pandemic even with a stronger effect than the pandemic itself. So the demand for externality becomes another reason for moving out. When we can only conduct activities around our home, the externality of the neighborhood will play a more important role in one's life. Such as green land, safety, less noise, low population density, and so on.

5 Conclusion & Implication

The research explores the response of Seattle's housing rental market to the impact of the COVID-19 pandemic. According to the analysis of GIS patterns before and after the pandemic, the pandemic did have an impact on the local rental housing market and this impact is actually not directly caused by the severity of the pandemic. This impact involves the rents and the structure of the local rental housing market. Rents all over Seattle have dropped to varying degrees over 2020 with the COVID-19 pandemic being a factor. The closer to the city center, the stronger the impact. The focus areas in the city center suffered the most dramatic rent decline. Work from home policy, the subsequent migration of residents, and the decline in the attractiveness of the city center are the main reasons that actually caused this phenomenon under the pandemic.

According to the basic statistical analysis, the research concludes that population density, tenure (rate of renter-occupied units), teenage group population under 17, working-age group population between 18 to 34, and high-tech employees (computer, engineering, and science) are the major factors that are associated with the significant decline in rent over the last year in Seattle. Based on their socioeconomic background, those zip codes in the city center are high in population density, proportion of high-tech employment, working-age population (18-34), and the renter-occupied units rate but low in teenage group population (0-17). These factors made the demand shift away from the city center and the subsequent rent decline. Combined with socioeconomic background in the center of Seattle, all the factors can be summarized in two points: people's capacity to leave the city center and the attractiveness loss of the city center. People's living style was greatly affected by the COVID-19 pandemic. Quarantine and work from home policy decreased the demand for

commuting and therefore the demand for housing in the center of the city was not as prevalent. The rents are a great indicator of the housing demand as supply takes time to catch up to demand. This can indicate a decreasing demand for living downtown as people move out of their areas of employment. Through the research about the impact of the COVID-19 pandemic on rents in the city of Seattle limits, we can conclude why and how the pandemic affects the rental housing market and know the factors that lead to a stronger rent change. We can probably prepare for the market change and achieve a potential new trend of people's living choices after the breakout of a pandemic like COVID-19 in the future.

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Appendix

Variables and Source

Variables	Classification	Data Period	Geographic level	Source	Link
Rent	Rent ($)	2018.1.1; 2019.1.1; 2020.1.1	Zip Code	Zillow Research	https://www.zillow.com/research/data/
	Rent Change Rate (%)	2019.1.1-2020.1.1; 2020.1.1-2021.1.1	Zip Code	Calculation	/
Covid-19 Data	Positive Cases (count)	2020.2.1-2021.1.1	Zip Code	kingcounty.gov	https://kingcounty.gov/depts/health/covid-19/data/daily-summary.aspx
	Positive Rate (per 1,000 residents)	2020.2.1-2021.1.1	Zip Code		
New Units Supply	New Unit Permit Issued (count)	2020.1.1-2020.12.31	Zip Code	seattle.gov	https://data.seattle.gov/Permitting/Building-Permits/76t5-zqzr
	New Unit Completed (count)	2020.1.1-2020.12.31	Zip Code		
	Issued Change Rate (%)	2020.1.1-2020.12.31	Zip Code	Calculation	/
	Completed Change Rate (%)	2020.1.1-2020.12.31	Zip Code		

Population	Population (count)	2019	Zip Code	kingcounty.gov	https://kingcounty.gov/depts/health/covid-19/data/daily-summary.aspx
	Population density (per acre)	2019	Zip Code	Calculation	/
Tenure	Renter-occupied Units Rates (%)	2019	Zip Code	IPUMS NHGIS & Calculation	https://data2.nhgis.org/
Age	0-17 (%) 18-34 (%) 35-59 (%) 60+ (%)	2019	Zip Code		
Occupation	Management, business, and financial (%) Computer, engineering, and science (%) Education, legal, community service, arts, and media (%) Healthcare practitioners and technical (%) Service (%) Sales and office (%) Natural resources, construction, and maintenance (%) Production, transportation, and material moving (%)	2019	Zip Code	U.S. Census Bureau	https://data.census.gov/cedsci/table?q=2021%20S2401&tid=ACSST1Y2019.S2401

Pearson Correlations, All Variables (except occupation)

Correlations

		RentChange20	RentChange19	Rent	PopulationDensity	Population	Tenure	CovidCase	CovidRate	Ageunder17	Age18to34	Age35to59	Ageover60
RentChange20	Pearson Correlation	1	-.184	-.032	-.768**	.484*	-.812**	.361	-.008	.813**	-.729**	.524*	.258
	Sig. (2-tailed)		.436	.893	.000	.031	.000	.118	.974	.000	.000	.018	.273
	N	20	20	20	20	20	20	20	20	20	20	20	20
RentChange19	Pearson Correlation	-.184	1	.279	.310	-.043	.278	-.040	-.070	-.236	.357	-.267	-.343
	Sig. (2-tailed)	.436		.233	.183	.856	.235	.866	.769	.316	.122	.256	.139
	N	20	20	20	20	20	20	20	20	20	20	20	20
Rent	Pearson Correlation	-.032	.279	1	.305	-.419	-.087	-.412	-.199	-.072	-.148	.421	.118
	Sig. (2-tailed)	.893	.233		.190	.066	.716	.071	.400	.761	.535	.065	.619
	N	20	20	20	20	20	20	20	20	20	20	20	20
PopulationDensity	Pearson Correlation	-.768**	.310	.305	1	-.398	.724**	-.320	-.076	-.818**	.634**	-.323	-.180
	Sig. (2-tailed)	.000	.183	.190		.082	.000	.169	.752	.000	.003	.164	.449
	N	20	20	20	20	20	20	20	20	20	20	20	20
Population	Pearson Correlation	.484*	-.043	-.419	-.398	1	-.383	.652**	.032	.450*	-.151	-.169	-.107
	Sig. (2-tailed)	.031	.856	.066	.082		.096	.002	.895	.046	.526	.475	.652
	N	20	20	20	20	20	20	20	20	20	20	20	20
Tenure	Pearson Correlation	-.812**	.278	-.087	.724**	-.383	1	-.257	.050	-.954**	.853**	-.685**	-.238
	Sig. (2-tailed)	.000	.235	.716	.000	.096		.274	.833	.000	.000	.001	.313
	N	20	20	20	20	20	20	20	20	20	20	20	20
CovidCase	Pearson Correlation	.361	-.040	-.412	-.320	.652**	-.257	1	.737**	.414	-.296	-.049	.206
	Sig. (2-tailed)	.118	.866	.071	.169	.002	.274		.000	.069	.206	.838	.384
	N	20	20	20	20	20	20	20	20	20	20	20	20
CovidRate	Pearson Correlation	-.008	-.070	-.199	-.076	.032	.050	.737**	1	.117	-.239	.035	.407
	Sig. (2-tailed)	.974	.769	.400	.752	.895	.833	.000		.624	.311	.882	.075
	N	20	20	20	20	20	20	20	20	20	20	20	20
Ageunder17	Pearson Correlation	.813**	-.236	-.072	-.818**	.450*	-.954**	.414	.117	1	-.830**	.577**	.206
	Sig. (2-tailed)	.000	.316	.761	.000	.046	.000	.069	.624		.000	.008	.384
	N	20	20	20	20	20	20	20	20	20	20	20	20
Age18to34	Pearson Correlation	-.729**	.357	-.148	.634**	-.151	.853**	-.296	-.239	-.830**	1	-.828**	-.659**
	Sig. (2-tailed)	.000	.122	.535	.003	.526	.000	.206	.311	.000		.000	.002
	N	20	20	20	20	20	20	20	20	20	20	20	20
Age35to59	Pearson Correlation	.524*	-.267	.421	-.323	-.169	-.685**	-.049	.035	.577**	-.828**	1	.436
	Sig. (2-tailed)	.018	.256	.065	.164	.475	.001	.838	.882	.008	.000		.054
	N	20	20	20	20	20	20	20	20	20	20	20	20
Ageover60	Pearson Correlation	.258	-.343	.118	-.180	-.107	-.238	.206	.407	.206	-.659**	.436	1
	Sig. (2-tailed)	.273	.139	.619	.449	.652	.313	.384	.075	.384	.002	.054	
	N	20	20	20	20	20	20	20	20	20	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Pearson Correlations, Percentage of Occupation

Correlations

		RentChange20	RentChange19	Rent	Business	Computer	Service	Education	Health	Sales	Natural	Production
RentChange20	Pearson Correlation	1	-.184	-.032	-.421	-.635**	.358	.340	.106	.457*	.539*	.250
	Sig. (2-tailed)		.436	.893	.065	.003	.121	.142	.656	.043	.014	.288
	N	20	20	20	20	20	20	20	20	20	20	20
RentChange19	Pearson Correlation	-.184	1	.279	.177	.463*	-.155	-.445*	-.396	.072	-.267	-.115
	Sig. (2-tailed)	.436		.233	.455	.040	.513	.049	.084	.763	.255	.631
	N	20	20	20	20	20	20	20	20	20	20	20
Rent	Pearson Correlation	-.032	.279	1	.478*	.359	-.456*	-.055	.006	-.279	-.198	-.324
	Sig. (2-tailed)	.893	.233		.033	.120	.043	.817	.980	.234	.404	.164
	N	20	20	20	20	20	20	20	20	20	20	20
Business	Pearson Correlation	-.421	.177	.478*	1	.712**	-.855**	-.025	-.072	-.277	-.691**	-.807**
	Sig. (2-tailed)	.065	.455	.033		.000	.000	.915	.764	.237	.001	.000
	N	20	20	20	20	20	20	20	20	20	20	20
Computer	Pearson Correlation	-.635**	.463*	.359	.712**	1	-.782**	-.101	.081	-.553*	-.862**	-.761**
	Sig. (2-tailed)	.003	.040	.120	.000		.000	.671	.734	.011	.000	.000
	N	20	20	20	20	20	20	20	20	20	20	20
Service	Pearson Correlation	.358	-.155	-.456*	-.855**	-.782**	1	-.279	-.330	.481*	.702**	.864**
	Sig. (2-tailed)	.121	.513	.043	.000	.000		.233	.155	.032	.001	.000
	N	20	20	20	20	20	20	20	20	20	20	20
Education	Pearson Correlation	.340	-.445*	-.055	-.025	-.101	-.279	1	.686**	-.325	-.155	-.379
	Sig. (2-tailed)	.142	.049	.817	.915	.671	.233		.001	.162	.514	.100
	N	20	20	20	20	20	20	20	20	20	20	20
Health	Pearson Correlation	.106	-.396	.006	-.072	.081	-.330	.686**	1	-.622**	-.160	-.233
	Sig. (2-tailed)	.656	.084	.980	.764	.734	.155	.001		.003	.501	.322
	N	20	20	20	20	20	20	20	20	20	20	20
Sales	Pearson Correlation	.457*	.072	-.279	-.277	-.553*	.481*	-.325	-.622**	1	.539*	.398
	Sig. (2-tailed)	.043	.763	.234	.237	.011	.032	.162	.003		.014	.082
	N	20	20	20	20	20	20	20	20	20	20	20
Natural	Pearson Correlation	.539*	-.267	-.198	-.691**	-.862**	.702**	-.155	-.160	.539*	1	.815**
	Sig. (2-tailed)	.014	.255	.404	.001	.000	.001	.514	.501	.014		.000
	N	20	20	20	20	20	20	20	20	20	20	20
Production	Pearson Correlation	.250	-.115	-.324	-.807**	-.761**	.864**	-.379	-.233	.398	.815**	1
	Sig. (2-tailed)	.288	.631	.164	.000	.000	.000	.100	.322	.082	.000	
	N	20	20	20	20	20	20	20	20	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Independent-samples Test, Rental Housing Market and COVID-19, Grouped by Focus Areas and Other Areas

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
RentChange20	Equal variances assumed	3.025	.099	-5.835	18	.000	-.1116067	.0191286	-.1517944	-.0714190
	Equal variances not assumed			-7.781	13.188	.000	-.1116067	.0143428	-.1425477	-.0806656
RentChange19	Equal variances assumed	.062	.806	1.721	18	.102	.0099867	.0058014	-.0022017	.0221750
	Equal variances not assumed			1.761	7.165	.121	.0099867	.0056712	-.0033613	.0233346
CovidCase	Equal variances assumed	2.149	.160	-.931	18	.364	-278.13333	298.62038	-905.51146	349.24480
	Equal variances not assumed			-1.366	16.644	.190	-278.13333	203.58176	-708.35389	152.08723
CovidRate	Equal variances assumed	1.284	.272	.213	18	.834	1.3133333	6.1622475	-11.6330682	14.2597349
	Equal variances not assumed			.251	9.570	.807	1.3133333	5.2319337	-10.4155739	13.0422405
Rent	Equal variances assumed	2.331	.144	.849	18	.407	75.93333	89.44081	-111.97483	263.84150
	Equal variances not assumed			.674	5.125	.529	75.93333	112.61477	-211.44188	363.30855
IssuedChange	Equal variances assumed	2.766	.114	-1.926	18	.070	-.9946667	.5165070	-2.0798076	.0904742
	Equal variances not assumed			-2.919	17.545	.009	-.9946667	.3407901	-1.7119740	-.2773593
Issued20	Equal variances assumed	.046	.833	.139	18	.891	24.733	178.552	-350.390	399.857
	Equal variances not assumed			.132	6.389	.899	24.733	187.382	-427.095	476.561
CompletedChange	Equal variances assumed	1.180	.292	-.558	18	.584	-.0839267	.1504958	-.4001066	.2322533
	Equal variances not assumed			-.869	17.958	.396	-.0839267	.0965636	-.2868334	.1189801
Completed20	Equal variances assumed	.731	.404	-.838	18	.413	-13.600	16.230	-47.699	20.499
	Equal variances not assumed			-1.049	11.150	.316	-13.600	12.960	-42.078	14.878