



## **SURAT TUGAS**

321/FBE/UKP/2021

Memenuhi permohonan dari Editor International Journal of Housing Markets and Analysis, maka ditugaskan kepada :

Nama : **Dr. Njo Anastasia, S.E., M.T.**

Nip : 00-017

untuk melakukan review makalah ilmiah bagi International Journal of Housing Markets and Analysis, dengan judul :

"The Impact of COVID-19 on Home Value in Major Texas Cities"  
(IJMH-05-2021-0058)

Demikian surat tugas ini dibuat untuk dapat dilaksanakan dengan sebaik-baiknya di Semester Genap 2020/2021.

Surabaya, 25 Mei 2021

Wakil Dekan



**Andi Jogi Christiawan, S.E., M.Si., Ak.**

Tembusan :

- Kaprogdi Manajemen
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Reviewer Jurnal Internasional Bereputasi

No	Nama Jurnal	Penerbit	ISSN	Terindeks	URL	Bukti
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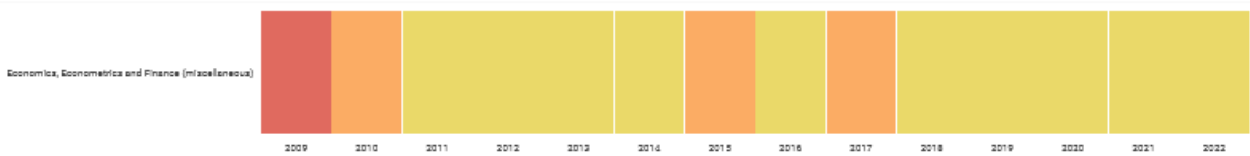
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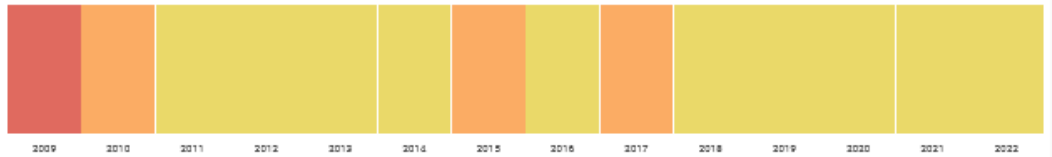


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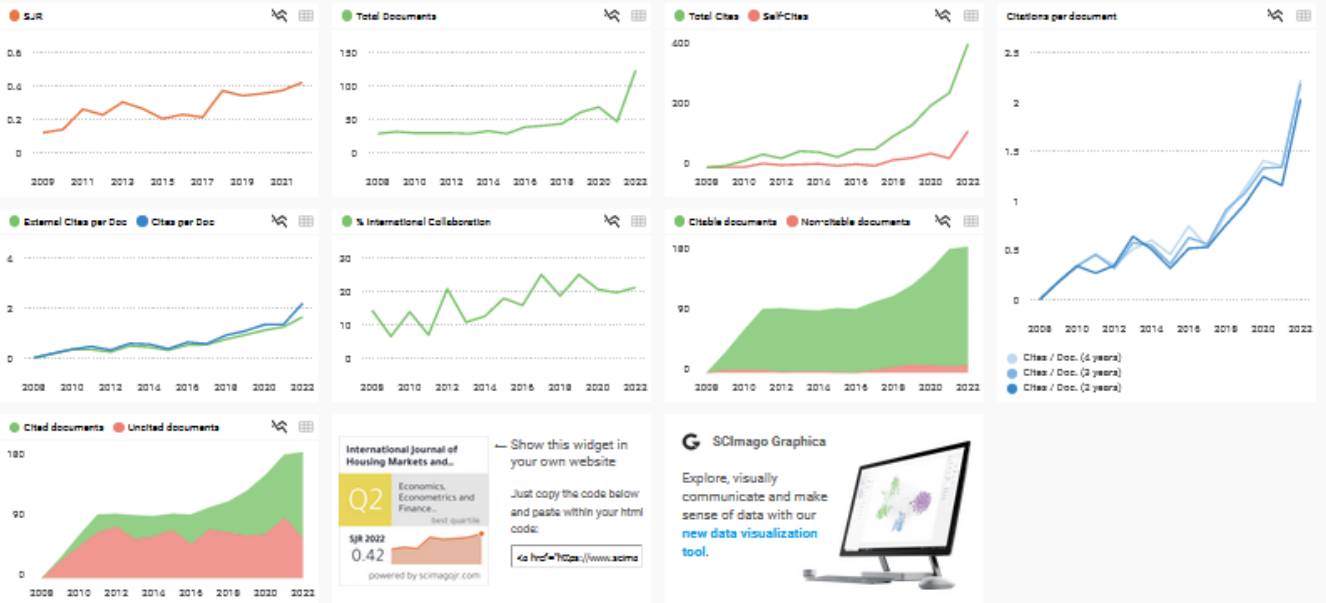
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Mon, May 24, 2:04  
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to me

24-May-2021

Dear Assoc. Prof. Njo,

Manuscript ID IJHMA-05-2021-0058 entitled "The Impact of COVID-19 on Home Value in Major Texas Cities" has been submitted to International Journal of Housing Markets and Analysis. The abstract appears at the end of this letter.

I would like to invite you to review this manuscript and hope that you will be able to accept my invitation. If you are unable to review at this time, I would appreciate you recommending another expert reviewer. Please click the appropriate link below to automatically register your reply with our online manuscript submission and review system.

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Sincerely,

Prof. Richard Reed

Editor, International Journal of Housing Markets and Analysis

[ijhma@ijhma.com](mailto:ijhma@ijhma.com)

## MANUSCRIPT DETAILS

TITLE: The Impact of COVID-19 on Home Value in Major Texas Cities

### ABSTRACT:

This study analyzed the impact of COVID-19 on housing price within four major metropolitan areas in Texas: Austin, Dallas, Houston, and San Antonio. The analysis intends to understand economic and mobility drivers behind the housing market under the inclusion of fixed and random effects.

This study used a linear mixed effects model to assess the socioeconomic and housing and transport- related factors contributing to median home prices in four major cities in Texas, and to capture unobserved factors operating at spatial and temporal level during the COVID-19 pandemic.

The regression results indicated that an increase in new COVID-19 cases resulted in an increase in housing price. Additionally, housing price had a significant and negative relationship with the following variables: business cycle index, mortgage rate, percent of single-family homes, population density, and foot traffic. Interestingly, unemployment claims did not have a significant impact on housing price, contrary to previous COVID-19 housing market related literature.

Previous literature analyzed the housing market within the first phase of COVID-19 whereas this study analyzed the effects of the COVID-19 throughout the entirety of 2020. The mixed model includes spatial and temporal analyses as well as provides insight into how quantitative-based mobility behavior impacted housing price, rather than relying on qualitative indicators such as shut down order implementation.

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Fri, Jun 4, 9:33 PM  
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to me

04-Jun-2021

Dear Assoc. Prof. Njo,

Thank you for submitting your review of IJHMA-05-2021-0058 for International Journal of Housing Markets and Analysis. We are very grateful for the contribution you have made to the journal by providing your review. We recognise the value that is added by our reviewers and would therefore like to thank you for your work, by granting you free personal access to up 40 Emerald journal articles (excluding Backfiles) within a three-month period.

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On behalf of the Editors of International Journal of Housing Markets and Analysis, we appreciate the valuable and efficient contribution that each reviewer gives to the Journal and we hope that we may call upon you again to review future manuscripts.

Yours sincerely,

Prof. Richard Reed  
Editor, International Journal of Housing Markets and Analysis  
[ijhma@ijhma.com](mailto:ijhma@ijhma.com)

Reviewer(s)' Comments to Author:

Referee: 1

Recommendation: Major Revision

Comments:

This study is interesting and it displays a renewal on housing value as a result of the COVID-19 pandemic. Use major or unique keywords within the study and write them in the order as it was written in the abstract. Please check the quotation source as well as the reference (e.g. Wong, 2008 about SARS, while the article talks about COVID-19 that began in 2020). It is better to write the variables in order rather than suddenly appearing on the research output (e.g. population). It is also preferred that the area of this study is made clear whether it is in Texas City or the State of Texas as well as the other cities.

Additional Questions: **1. Originality:** Does the paper contain new and significant information adequate to justify publication? (i.e. is it a contribution to knowledge?):

This study displays new information in the study development of property value resulted by the COVID-19 pandemic. It ought to be more specifically explained on the choosing of Texas as the area of study, perhaps this city has the largest population affected by COVID or other reasons that support this study. Also, a specific reason on why this study is conducted in a temporal, spatial, and economic manner.

**2. Relationship to Literature:** Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored to your knowledge?:

It is better to concisely explain the grand theory of property value regarding both macro (macro economy) and micro (property attribute) factor as a foundation to further develop the study, therefore supporting this study and making it more interesting. Micro and macro economy factors pros and cons influence the formation of increasing and decreasing property value, one of them being the COVID-19 pandemic, as well as an explanation on the measuring instruments applied on these two factors.

**3. Methodology:** Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the research methods employed appropriate?:

This research has been well designed and well described, however it ought to be made clear with the research variable and indicators (measuring instruments) that support this study. On the data part, the measuring instruments ought to be written in order to identify the temporal, spatial, and economic manners, or identification of the macro and micro factors as well as their units (% , m<sup>2</sup>, US\$, etc.) clearly, to help understand the use of the measurement instruments in future studies. For the titles of study area, data, and research method, it is better to combine it (research methodology) according to the writing format of IJHMA.

**4. Results:** Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?:

There is a difference in the research indicator (population density) of Table 1 and Table 2. Figure 5 (Ui) and Figure 6 (Vit) are part of a model, however it is difficult to understand the explanation and the process namely city level unobserved and spatio temporal random, and also the unit is not displayed in the figures.

**5. Implications for research, practice and/or society:** Does the paper identify clearly any implications for research, practice and/or society? Does the paper bridge the gap between theory and practice? How can the research be used in practice (economic and commercial impact), in teaching, to influence public policy, in research (contributing to the body of knowledge)? What is the impact upon society (influencing public attitudes, affecting quality of life)? Are these implications consistent with the findings and conclusions of the paper?:

The implication of the research result has been explained, yet it needs to be emphasized that this research only applies in Texas and not in America as a whole, so there is no bias in the result of the study.

**6. Quality of Communication:** Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.:

The communication quality in this writing is generally well done, however explanations are sometimes incoherent (not in order) Please recheck the grammar of this writing as there are still mistyping found.

# The impact of COVID-19 on home value in major Texas cities

Mira R. Bhat, Junfeng Jiao and Amin Azimian

*Department of Urban Information Lab, The University of Texas at Austin,  
Austin, Texas, USA*

## Abstract

**Purpose** – This study aims to analyze the impact of COVID-19 on housing price within four major metropolitan areas in Texas: Austin, Dallas, Houston and San Antonio. The analysis intends to understand economic and mobility drivers behind the housing market under the inclusion of fixed and random effects.

**Design/methodology/approach** – This study used a linear mixed effects model to assess the socioeconomic and housing and transport-related factors contributing to median home prices in four major cities in Texas and to capture unobserved factors operating at spatial and temporal level during the COVID-19 pandemic.

**Findings** – The regression results indicated that an increase in new COVID-19 cases resulted in an increase in housing price. Additionally, housing price had a significant and negative relationship with the following variables: business cycle index, mortgage rate, percent of single-family homes, population density and foot traffic. Interestingly, unemployment claims did not have a significant impact on housing price, contrary to previous COVID-19 housing market related literature.

**Originality/value** – Previous literature analyzed the housing market within the first phase of COVID-19, whereas this study analyzed the effects of the COVID-19 throughout the entirety of 2020. The mixed model includes spatial and temporal analyses as well as provides insight into how quantitative-based mobility behavior impacted housing price, rather than relying on qualitative indicators such as shutdown order implementation.

**Keywords** Housing market, Economy, COVID-19, Median home price, Mixed model, Mortgage rate

**Paper type** Research paper

## Introduction

The outbreak of COVID-19 in the Texas, along with the entire USA, resulted in major repercussions on the economy and drastically altered people's lives. COVID-19 is a global, respiratory contagion that has limited mobility and thus triggered a series of events, such as the negative shock to household income, interest rate cuts, forbearance on mortgage payments, fluctuations in stock prices and the rising expectation on inflation rates (CNN 2020).

These factors' effect on the housing market varies by region with certain areas having depressed demand from significant downward pressure on housing price, and others experiencing higher housing demand induced by the central bank's unprecedented monetary easing. Lower housing supply owing to restrictive mobility policies as well as sellers' reluctance to supply the houses due to fear of infection additionally affect the



housing market and result in higher housing prices (Zhao, 2020). COVID-19 related factors may have also introduced frictions and transaction costs that negatively affected prices and liquidity within the housing market, especially within urban centers. According to Wang (2021), the national transaction volume dropped by 42.2% at the end of April in 2020 but increased by 23.1% in September. Overall, studies have shown that housing transactions decreased with a surge in housing markets following, but the market appears to have slightly rebounded.

Historically, interest rate shocks significantly and negatively affect housing prices while monetary policy shocks tend to not have a sizeable impact. Notably, uncertainty shocks were important in explaining fluctuating housing prices according to global studies conducted by Hirata *et al.* (2013) and Strobel *et al.* (2020) with Strobel *et al.* (2020) finding that uncertainty shocks reduced housing prices by 1.4% after controlling for fixed effects. Moreover, the largest effects of uncertainty and demand shocks were found in states that exhibited relatively high housing price volatilities. Although Texas does not exhibit high housing price volatility, its major cities have been greatly affected by the pandemic and provide insight into the drivers behind the COVID-19 housing market. Furthermore, COVID-19 has created highly levels of uncertainty throughout 2020 and is an optimal factor to analyze within the housing market.

Specifically looking at the economic shock of Great Recession from 2007 to 2009, Mehrotra and Sergeyev (2021) emphasized the demand effects of household deleveraging. Meaning, falling house prices reduced household consumption that was linked with unemployment rates. In contrast, Abbate *et al.* (2016) found housing prices to persistently rise following financial shock, modeled from vector autoregressions. Killins *et al.* (2017) analyzed the effect oil shocks, following the Great Recession, had on the housing market and found the reaction of housing markets to oil price shocks varied significantly depending on whether the change in oil prices is prompted by demand or supply shocks in the oil market. Within our analysis, we further explored the influence of demand and supply shocks to the COVID-19 housing market as well as the impact of other economic variables.

Owing to the competing analyses of historical crises and the limited COVID-19 housing related literature, it remains unclear which COVID-19 induced factors significantly influence the housing market and housing price (D'Lima *et al.*, 2020). In light of the disruption COVID-19 has afflicted onto the housing market, this study aimed to identify the temporal, spatial and economic impacts of COVID-19 on housing prices among major cities in Texas to understand the various driving forces of the housing market developments.

## Literature review

Previous research explored the impact of COVID-19 on housing price mainly within China, the epicenter of the virus in its initial stages (Cheung *et al.*, 2021; D'Lima *et al.*, 2020; Fang *et al.*, 2020). They specifically observed the effect of shutdown orders and contagion rates on price, primarily finding that prices in states with shutdown orders decreased as the COVID-19 contagion rate increased. The rationale behind analyzing shutdown or lock down orders was that they inevitably disrupted the search processes of property buyers and subsequently lengthened sale completions. As a result, COVID-19 related factors introduced market frictions to the matching process and negatively affected the transacted prices and liquidity. Shutdown orders were representative of mobility levels, but moving forward, foot traffic data will be representative of mobility. Granular mobility data is a quantitative measure of travel behavior that allows for the observation of patterns and correlations rather than relying on qualitative measures that cannot capture the strength of mobility changes (Dong *et al.*, 2017; Yabe *et al.*, 2020).

Cheung *et al.* (2021) and Qian *et al.* (2021) discussed how Wuhan, China was an optimal case study because it excluded effects of countercyclical measures, such as interest rate cuts and mortgage policy changes. However, policy changes and mortgage/interest rates greatly affect housing prices, which were taken into account in our analysis of major Texas cities. Although median housing price was not on an upward trend as was the case in Wuhan, China, the relatively stable housing prices in major Texas cities allowed for the effects of the pandemic outbreak to be accurately measured in either direction, making major Texas cities an excellent case to show COVID-19's effects on housing prices.

COVID-19 literature primarily focuses on the spread of the virus and its effect on transportation with findings centering on constrained mobility (Jiao *et al.*, 2021; Jiao and Azimian, 2021a, 2021b). Although COVID-19 housing market analyses are limited, Zhao's (2020) zip code level analysis of the USA revealed that the Federal Reserve's unprecedented monetary easing accelerated the growth rate of median housing price during the first four months of the pandemic. Additionally, Zhao claimed that the increase in housing demand in response to lower mortgage interest rates displayed a structural break since March 2020. Meaning, housing demand grew at an unexpected and accelerated rate. These results indicated either the existence of "fear of missing out" or COVID-19 induced fundamental changes in household behavior. Furthermore, Yoruk (2020) studied the housing market in 50 major US cities during the early effects of COVID-19 and asserted that the housing market is collapsing and effecting all major cities, regardless of the intensity of virus' spread or state level policy intervention. Wang (2021) further explored this effect by specifically investigating the effect of COVID-19 on housing prices in five areas in the USA that vary in economic features and implementations of stay home orders: Houston, Santa Clara, Honolulu, Irvine and Des Moines.

D'Lima *et al.* (2020) discussed the importance of implementing fixed effects within housing market analyses, such as space and time, to focus on price effects and to obtain rough but market-based estimates of the average costs and possible benefits of COVID-19. To include fixed and random effects, a linear regression analysis was most suitable for our analyses in predicting housing price because it is able to control for spatial and temporal variables. Within our regression, mobility/foot traffic data rather than shutdown policy implementation was used, allowing for a quantitative measure of travel behavior instead of relying on exploratory analysis primarily found in previous literature. Based on studies by Cheung *et al.* (2021) and D'Lima *et al.* (2020), mortgage rate and single family home variables were included in the regression as they significantly affect housing price. Although a business cycle index (BCI) variable was absent from previous housing market studies, it is included in our regression as BCI provides an overarching view of economic health within major cities. BCIs are constructed based on aggregated movements in the local area unemployment rate, nonagricultural employment, inflation-adjusted wages and inflation-adjusted retail sales. These components are statistically optimized for each metropolitan area to best capture the underlying cyclical movements in the local area economy and predict long-term growth using real metro GDP. Current literature analyzing the US housing market during COVID-19 is broadly based, rather than analyzing a particular region, and was mainly conducted during the initial stages of the pandemic. As housing markets vary across the USA, we built off our predecessors by specifically analyzing major Texas cities to measure the effect of COVID-19 on the Texas housing market and housing price.

### Study area

The study areas for this analysis were major metropolitan areas in Texas: Austin, Dallas, Houston and San Antonio. Specifically, zip codes within each respective city were analyzed

and aggregated in terms of their COVID-19 cases, foot traffic and unemployment claims. However, a macroeconomic lens was taken for the other variables in our study such as median housing price, percentage of single family homes, mortgage rates and BCI. The four major cities of the state of Texas were chosen as a case study owing to data availability and owing to Texas being one of the most affected states from COVID-19.

## Data

Within the analysis, median housing price was predicted by single family home, mortgage rate, population density, COVID-19, BCI, unemployment claim and foot traffic data. Redfin's Data Center has direct access to data from local listing services as well as insight from real estate agents across the country and was able to provide housing price data grouped by metropolitan area on a weekly basis. The US Census Bureau released reports including summary statistics of the percentage of single family homes and population densities (on a per square mile basis) in metropolitan areas, relatively stationary variables; these variables were constructed using the latest reports from 2007 on single family home percentage and from 2020 on population density estimations. FRED Economic Data, which tracks the 30-year fixed rate mortgage average in the USA on a weekly basis, provided mortgage rate data across the four cities. Although FRED data represents the USA as a whole, mortgage rates are a macroeconomic indicator and variation within rates starts at the national level with changes affecting each state and metropolitan area in a similar manner (McGibany and Nourzad, 2010). The Texas Department of State Health Services provided a daily time series tracking new COVID-19 cases for each Texas county. The counties were aggregated, respectively, for each city on each day and then transformed into a weekly time series by adding seven days' worth of COVID-19 data starting on the date 1 January 2020. Furthermore, the Federal Reserve Bank of Dallas provided a monthly collected BCI data set for each metropolitan area, which was crucial to include in the regression as BCI is a quantitative measure that indicates economic expansion or recession. The BCI data was transformed from a monthly time series into a weekly time series by interpolating the data. Google mobility reports provided foot traffic data that was tracked as a percent change from baseline activity, which Google defined as the average of the last two weeks of February 2020, before the pandemic deeply affected the USA. Google's daily mobility data on Texas was filtered by zip code and aggregated together in the same method as the new COVID-19 case variable. Moreover, the Texas Workforce Commission tracked unemployment claims on a weekly basis per county and was aggregated by grouping together each city's respective counties. Overall, this data set was represented as a weekly time series during 2020 for housing, mobility and economic variables for each city: Houston, Austin, Dallas and San Antonio. Descriptive statistics for the variables used and this data study are listed below in Table 1.

COVID-19 within the four cities follow the same pattern, which was most likely owing to Texas as a whole being under the same state policies regarding the virus. New cases of COVID-19 peak around July 2020 during the summer, when people were increasing their mobility activity. Additionally, there may have been a public desensitisation to the virus after the previous six months of continuous quarantines and lockdowns (Abdullah *et al.*, 2020; Pawar *et al.*, 2020; Shakibaei *et al.*, 2021). After the peak in July, new COVID-19 cases steadily decreased to a relatively low point around September. This trend may be because of the principle that people have a lagging reaction to COVID-19 (Jiao *et al.*, 2021). However, new cases increased again in October with a spike of cases within December 2020 owing to excitement surrounding news of an effective vaccine, resulting in an increase in mobility. As seen from the Figure 1, Dallas contained the largest portion of new COVID-19 cases between



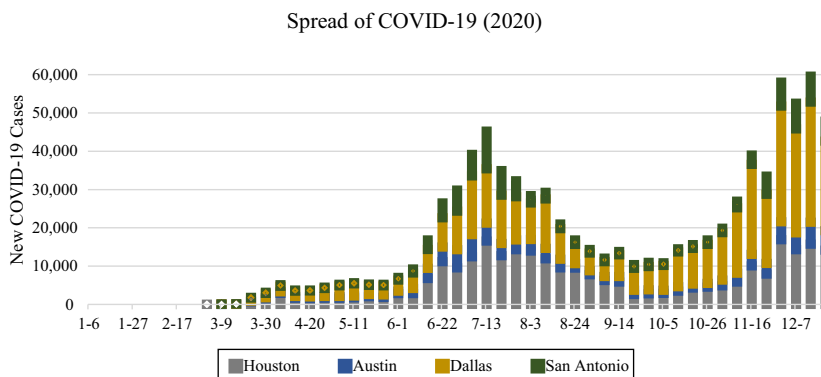
Although the business cycle indices of the four cities follow a similar pattern, they each are on different levels. From [Figure 2](#), there was a decrease in BCI near the beginning of March, when the pandemic started to affect Texas, but slowly increased overtime towards the end of 2020. Notably, BCI did not return to its previous pre-COVID-19 levels for any of the major Texas cities. Austin remained as the highest measure of BCI with Dallas, San Antonio and Houston following suit. Austin may have had the highest BCI because of its growth potential in comparison to Houston, Dallas and San Antonio, which are relatively more established than Austin. BCI is an important measure of economic expansion or recession and its inclusion in the regression illustrated the relation between housing price and economic health.

Unemployment claims dramatically increased towards the end of March 2020, when the pandemic deeply affected Texas. Overtime, unemployment claims decreased with a few spikes around May and July. The four cities follow relatively the same pattern because the pandemic widely affected Texas and the USA in a similar manner, indiscriminately. When the pandemic first arrived in March, businesses were unprepared for the impact COVID-19 had on the work environment, but the overall decrease in unemployment claims towards the end of 2020 seems to indicate the economy either shows signs of rebounding or that

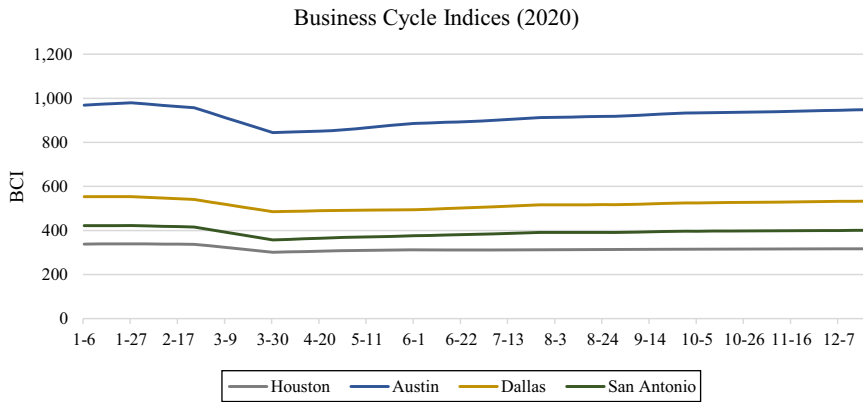
**Table 1.**  
Summary statistics  
of variables for  
regression analysis

Variables	Min	Max	Mean	Median	SD
<i>Dependent variable</i>					
Median housing price (\$)	222,000.00	375,750.00	289,824.20	275,122.00	41,282.59
<i>Independent variable</i>					
Single family house (%)	0.46	0.67	0.58	0.60	0.08
Mortgage rate (%)	2.66	3.72	3.12	3.10	0.30
New COVID-19 cases	0.00	31,386.00	48.39	4,026.59	5,654.38
BCI	301.05	979.56	536.47	453.87	233.15
Unemployment claims	657.00	63,280.00	11,083.51	6,447.50	13,123.28
Foot traffic (%)	−168.77	78.90	−27.38	−28.45	50.82
Population density	2,148.17	4,295.17	2,994.32	2,766.99	866.22

**Figure 1.**  
COVID-19 across  
major Texas cities







**Figure 2.**  
BCI across major  
Texas cities

businesses have adapted to the current situation surrounding the virus. An example of a major COVID-19 work related adaption includes the transition of workplace activity to an online setting within the safety of people's home (Figure 4).

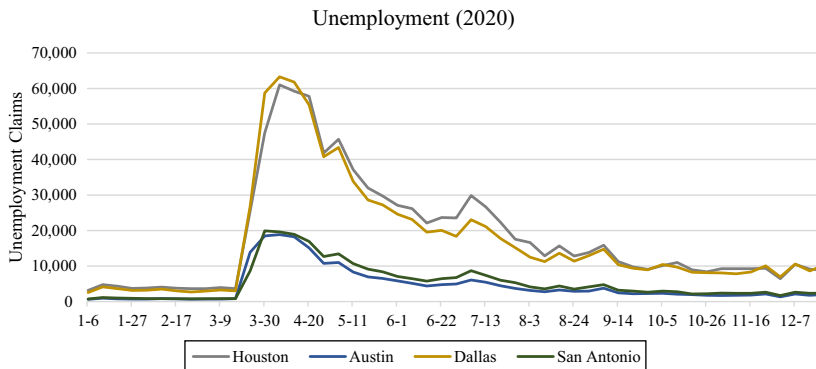
Mobility within the four cities generally follow the same pattern with major decreases in foot traffic activity towards the end of March 2020 and late August 2020. In relation to Figure 3, it is observed that mobility and unemployment claims appear to be inversely related, with an increase in unemployment claims when there is a decrease in foot traffic activity. This bolsters the link between mobility and the economy where efficient, used transportation measures increase overall economic health.

### Research methods

To undertake an analysis of the effects of above-mentioned factors on median housing price across the Texas cities during the COVID-19 pandemic, we proposed a linear mixed effects model with spatial and temporal random effects, which can be expressed as follows:

$$Price_{it} = \beta_0 + \beta X + u_i + v_{it} \quad (1)$$

where  $X$  is a vector of explanatory variables.  $\beta$  is a vector of unknown parameters.  $u_i$  represents spatial random effect term that captures city-level unobserved factors.



**Figure 3.**  
Unemployment  
claims across major  
Texas cities

Unobserved factors are variables that cannot be measured or captured but can impact the dependent variable and enhance a traditional linear regression model.  $v_{it}$  stands for spatio-temporal random effect term that accounts for variations across the months for each city. This study was conducted in a temporal, spatial, and economic manner to account for the varying sizes of the cities, ranging from mid to large size and to account for other possible factors that could not be included in the model, such as square footage.

Results and analysis

The price of a house is tied to the supply and demand for housing, in which COVID-19 has worsened both sides the economy. There are fewer houses available due to COVID-19, with an increasing volume of prospective buyers bidding up the price to obtain one. The regression results below (Table 2) align with the current state of the housing market as seen through new COVID-19 cases significantly and positively impacting median housing price.

The regression indicated that an increase in new COVID-19 cases resulted in an increase in housing price. COVID-19 constricted supply and increased demand for housing, creating a mild crisis and during financial downturns, people may be reluctant to make heavy financial decisions owing to the uncertainty in their lives. Meaning, people who might have

Figure 4.  
Foot traffic levels  
across major Texas  
cities

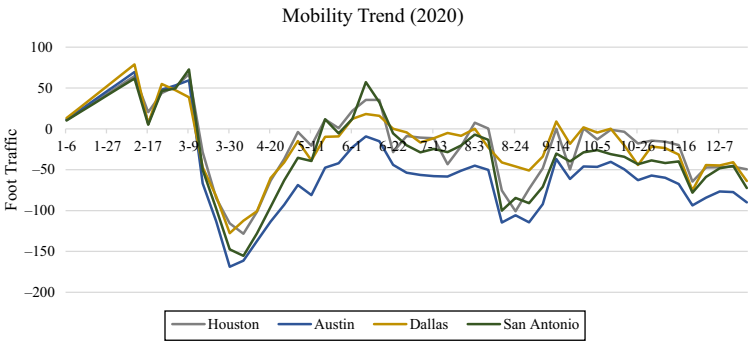


Table 2.  
Mixed model  
multiple regression  
results (N = 378)

Independent variables	Dependent variable: median housing price			
	Coefficient	Standard error	Z score	P > Z
Intercept	932,729.100	65,714.440	14.190	0.000*
Single family house	-595,674.300	55,310.510	-10.770	0.000*
Mortgage rate	-33,924.450	3,308.497	-10.250	0.000*
New COVID-19 cases	0.353	0.178	1.980	0.048*
BCI	-135.453	26.795	-5.060	0.000*
Ln (unemployment claims)	-1,352.800	1,220.304	-1.110	0.268
Sqrt (foot traffic)	-29.151	14.419	-2.020	0.043*
Population density	-35.528	2.881	-12.330	0.000*
$\sigma_u$	0.000	—	—	—
$\sigma_v$	5,092.017	—	—	—

Notes: Log likelihood = -2,137.9999; Wald chi2(7) = 2,466.62, prob > chi2 = 0.0000; LR test vs linear model: chi2(2) = 37.06, prob > chi2 = 0.0000. \*Indicates significant at  $\alpha = 5\%$

listed their homes chose not to during 2020 with others possibly taking their homes off the market as COVID-19 spread across the country. COVID-19 additionally slowed the buying process as people may have been hesitant to display their homes for fear of contracting and spreading the virus. Therefore, the limited housing supply increased bid prices and furthered the housing issue.

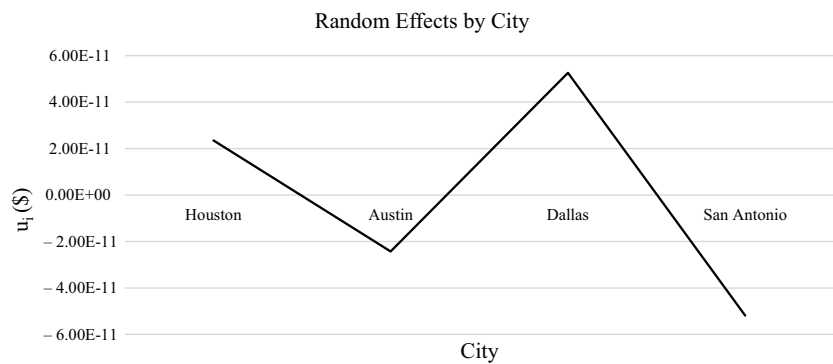
All variables except for unemployment claims were significant in predicting median house price (Table 2). This was surprising considering previous literature by Irandoust (2019) and Wang *et al.* (2018) discovered that unemployment variables were key drivers of housing price, with Irandoust (2019) observing a unidirectional causality. However, their research was conducted within major European cities and Australia, respectively, whereas our analysis was within the USA: specifically, major Texas cities. Nonetheless, explanations for this result remains unclear and future research can delve further into the relationship between unemployment and housing price within the USA.

Foot traffic was significant with a negative coefficient, indicating that as foot traffic increased, housing price decreased. This can be attributed to the fact that efficient, used transportation systems can create a smoother economy, but because of COVID-19 inducing decreased levels of foot traffic, decreased level of economic activity resulted and negatively impacted housing price. As BCI increased, housing price decreased, demonstrating that despite indications of an economic recession, housing price would increase. Population density is significant because the volume of bids for housing will negatively affect housing price owing to increased demand.

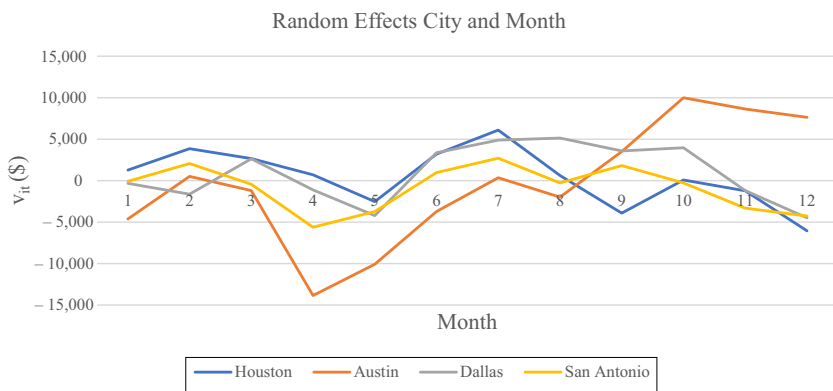
Moreover, several studies, at the national, international and regional levels have shown that mortgage rates exert a significant negative effect on housing prices (Englund and Ioannides, 1997; McGibany and Nourzad, 2010; Reichert, 1990; Thom, 1983). Mortgage rate was significant and negative in the regression with economic theory suggesting that housing prices rise when mortgage rates fall (McGibany and Nourzad, 2010). The significance of mortgage rates strengthen previous findings by Wang *et al.* (2018) who claimed mortgage interest rates were a principal driver of housing price and their movements aided in the detection of housing bubbles. This is because most home sales being credit financed, so the lower borrowing costs help increase the number of households on the demand side of the market. When demand increases, along with the assumption that the supply of housing is not perfectly elastic, an increase in the purchase price of housing should follow. Mortgage rates decreased in 2020 as a COVID-19 financial package aimed to promote monetary easing as a result of decreased income levels. However, lower mortgage rates can entice buyers and increase demand, subsequently increasing housing price.

Based on Figure 5 and the estimated standard deviation corresponding to the spatial random effect term in Table 2, the magnitude of the city-level effects is close to zero and thus, insignificant. However, the large magnitude of spatio-temporal effects (Figure 6) highlights the presence of some unmeasured city-level factors that change over time. For example, city-level policies/regulation or business policies within each city may have varied over time. Another example for an unmeasured risk factor includes changing perceptions toward COVID-19 outbreak over time. Jiao, Bhat, and Azimian (2021) noted a desensitization to COVID-19 in Houston, TX after mid-July 2020 through their analysis of mobility behavior. Considering the lack of available vaccines in 2020, the shifting attitudes concerning COVID-19 affect its spread and subsequently housing price (Table 2). As shown in Figure 6, there was a significant drop in Austin housing prices in April 2020 following the implementation of mobility restrictive policies in late March 2020. However, prices rebounded and tended to increase until December 2020 as a result of economic shocks and changes in social behaviors. In contrast, Dallas, San Antonio and Houston had steady

**Figure 5.**  
Measuring spatial  
random effects across  
major Texas cities



**Figure 6.**  
Measuring spatio-  
temporal random  
effects across major  
Texas cities



housing price trends, on average, during 2020. The proposed model is useful for planning and practice purposes as the inclusion of random effects confirms the presence of unmeasured risk factors across space and time (Azimian *et al.*, 2021). This highlights the need for the further identification of meaningful factors that can be used for planning and policy purposes.

**Discussion**

Our analysis highlights the effects of COVID-19 and COVID-19 induced economic conditions, which can lead to unintended consequences such as growing levels of inequality in the Texas housing market. This finding is consistent with Zhao's (2020) evaluation of the negative repercussions of lower mortgage rates on housing price in the USA. Rising demand and limited supply benefit homeowners who are experiencing their home values increase. However, for those who have not been able to take advantage of recent monetary easing and historically low mortgage rates, navigating the current market may be stressful. As a result, a growing share of Americans may be shut out of the housing market because of the financial conditions restricting them on the demand side.

COVID-19 brought economic hardship to homeowners across Texas and the USA with the limited financial packages provided by the US Government leaving some Americans in need of housing without the means to obtain it. Although the endorsement of monetary

easing aimed to alleviate financial burdens faced by homeowners, it may have weakened the housing market. Further monetary easing could increase housing value on the supply side while continuing to strain the demand side. Instead, government leaders should increase their financial packages to American citizens through further distribution of stimulus checks. Although the US Government released a one-time transfer to eligible Americans in 2020, this resulted in relatively low rates of spending with (Coibion *et al.*, 2020; Kaplan *et al.*, 2020) finding no meaningful effect on labor-supply decisions or housing relief from these transfer payments.

Despite the nationwide vaccine distribution in 2021 and the possibility of an economic upturn, the current instability within the Texas housing market may be a consequence of lacking regulation on the market during the first half of the pandemic in 2020. Yoruk's (2020) predictions of an upcoming recessionary period and housing crisis may come to fruition if prices continue to increase without signs of economic expansion, as indicated through the inverse relation between BCI and housing price (Table 2).

## Conclusion

The regression results indicated that an increase in new COVID-19 cases negatively affected housing price. Meaning, as COVID-19 spread across major Texas cities, housing price increased which in part can be explained by the significance of the mortgage rate variable. A decrease in mortgage rate, which was experienced throughout 2020, resulted in an increase in housing price contrary to its intention as a method of monetary easing. Monetary easing intended to alleviate the financial burden felt by homeowners during COVID-19, but it ultimately inflated housing priced and worsening both sides of supply and demand in the Texas housing market. Notably, this analysis and its research implications apply to the Texas housing market and cannot be directly translated to reflect the entire American housing market.

Notably, foot traffic, BCI and percent of single family homes had a negative relationship with housing price across the four Texas cities. Moreover, the results illustrated that unobserved spatial and temporal effects impact housing price, with the effects reducing housing price across all cities except Austin. Limitations within this study stem from the limited housing variables available on a weekly basis and on a metropolitan level. For instance, square footage is a leading predictor of housing price, but its data was unavailable for Dallas and San Antonio (Redfin, 2021). Therefore, the variable was not included in the mixed model regression as the study was conducted across all four cities. Moreover, variables such as COVID-19 risk perceptions and demographics as well as building age and number of business parcels are beneficial predictors of land value and housing price according to Jiao, Hansen, and Azimian (2021) but were not included owing to the constraints of the data. Owing to lack of data within this study, random effect terms were used to counteract this major limitation and capture factors across space and time. Future studies would benefit from the inclusion of a square footage variable and additional transit related factors such as vehicle miles traveled (VMT) within COVID-19 related analyses. VMT data provides insight into local traffic levels and the efficiency of public transit systems, which can assist in evaluating policies and strategies that support improved public health outcomes.

Overall, this study could assist policymakers in identifying the agents behind the current state of the housing market, particularly focusing on the negative impact of mortgage rates, mobility and COVID-19. Understanding these market movements can aid in creating effective policies aimed towards mitigating housing supply and demand disparities.

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