The use of Apple mobility index, Night time light index, and Covid-19 infected cases to indicate House Price Index during the COVID-19 pandemic

Presented to

Assist.Prof. Nattapong Puttanapong

By

Chanoknan Sriwichit 6104641441

A report submitted in partial fulfillment of
the requirements for EE 406 Contemporary Economic Issues

Thammasat University
Semester 1 / 2021

Table of Content

Introduction

The world economy has changed drastically because of the COVID-19 pandemic. According to Jones, Palumbo and Brown (2021), there is an estimation from the IMF that in 2020, the Economy went down by almost 5%. And this has caused People's behavior to change, which also has significant impacts on the economy. For example, according to Singlor (2021), during the pandemic, the House Price Index in many countries had a major increase. One of the factors that contributed to the increasing of house prices is because many people were able to work from home during the pandemic. This led to an increase in demand for larger accommodation areas. Hence, increasing the real estate price. Moreover, in the housing supply side, the construction cost also increased. This is due to the increased price of construction materials due to shipping and logistics delay, which is also caused by the pandemic. Overpricing of the real estate market can also cause additional issues such as higher levels of inequalities. According to the IMF (2021), overpricing of the housing market will cause higher levels of inequalities because only the rich can afford to buy all the houses and lands, and the poor will only be able to afford renting from the rich. This is why it is important for the government to monitor this issue closely and make sure that the housing prices are not too overpriced.

This study tries to use alternative indicators including Apple Mobility Index dataset, COVID-19 infected cases dataset, and Nighttime Light Index dataset to predict and monitor the conventional indicator, House Price Index (HPI). The goal for this is to be able to predict the HPI using the other alternative indicators, which will allow for further insights into customer behavior analysis in the housing market during the pandemic.

Literature review

This research focuses on finding alternative data to indicate on Property sectors during the COVID-19 pandemics. There are many related researches on property sectors and also non-traditional indicators which can be separated into 3 main sections;

1. **Literature related to Research Method**

    - Yusof and Ismail (2012) explained the fluctuating house price in Malaysia by using Multiple regression and Hedonic regression analysis. The study found out that Local is the most important factor that influences the housing price.

    - Wang (2016) used the regression to explain the relationship between demand for houses and mortgage premiums. The result stated that an increase in mortgage premium will cause the house price to increase within the next 3 years.

    - Zhang (2021) stated that housing prices can be partially predicted by using multiple linear regression models.

    - Ahmed (2020) studied macroeconomics factors on House Price Index in Saudi Arabia. The result turned out that the Consumption Perception Index (CPI) has the most influence on House Price Index (HPI).

2. **Literature related to Datasets**

    - Robert (2021) studied using Nighttime Light data to analyze the current level of economics in Morocco. In this study, the researcher found that Night time Light can be used to analyze and predict the quarterly GDP level of Morocco. This can not only be used to analyze GDP in normal situations, it can also be used to indicate GDP of Morocco during the COVID-19 pandemic as well.

    - Hepşen and Vatansever (2012) indicated in their study that there are relationships between Property Price Index and alternative investments in Dubai. In this case, the alternative investments in the study refers to gold and foreign trades.

- Putra and Arini (2021) studied the effect of people's mobility toward Economic activity by using Google Mobility trends and Apple Mobility trends. The results of this research suggest that mobility has an impact on Regional GDP growth. An industry cluster also has an impact on people mobility and Regional growth.

- Limpanasukhon (2015) studied economic factors that can have an impact on the House Price Index. This includes the House Price Index of Single detached Houses, Condominiums, and Townhouses. From the research, it can be derived that the Construction Price Index has a positive correlation with the House Price Index and the Townhouse Price Index.

- Sun et al. (2020), Electricity consumption can be best estimated by using the combination of Nighttime Light index and population.

- Ruenthip and Thavonlun (2020) used the Apple Mobility Index to analyze the tourism industry in Thailand. The result suggested that Apple Mobility Index is a high frequency indicator to indicate the occupancy rate, people pattern of traveling and the recovering rate of each province.

- Coccia (2021) found that the number of COVID-19 infected cases is higher in countries with a long period of lockdown measures. This also affects the GDP growth of countries. Countries with longer periods of lockdown had lower growth than short lockdown period countries.

3. Literature related to Sub-topics

- Brueckner, Brueckner and Lin (2021), Work from Home (WFH) during the COVID-19 pandemic has influenced the price of houses and rental rates to be lower because people relocated to cheaper areas.
- Satirapipatkul (2020) found that during the COVID-19 pandemic, people changed due to the fact that their income is insatiable. Therefore, both real estate demand and supply was reduced.

Research Gap

As the time passes, there are many new ways to estimate economic activities, especially during the COVID-19 pandemic, such as Apple Mobility index, COVID-19 infected case and Nighttime Light data. However, there are currently only a few studies that are based on similar datasets that can be used as references. Moreover, most of the research that uses these data are usually only focused on predicting and analyzing GDP level. Therefore, there is a lack of studies on how these data can be used in other economic sectors.

Data and Research methods

Data

In this study, the data used can be separated into two main categories, which are Conventional indicators and Alternative indicators. Conventional indicators refer to the data that I am trying to predict using different models. And alternative indicators refer to the data that are used to predict the conventional indicators.

1. Conventional Indicators

    - House Price Index (HPI)

The Housing Price Index during the period of January, 2020 and September, 2021 was used as the conventional indicator for the study. According to the Bank of Thailand (n.d.), the House Price Index was composed of 4 indexes; The condominium Price Index (CMPI), the townhouse Price Index (THPI), the Single detached House Index (SHPI), and Land Price index (LPI). The Housing Price Index was calculated from mortgage loans data that were collected from 17 different commercial banks in the Bangkok area and surrounding vicinities (Samut Prakan, Nonthaburi, Pathum Thani, Nakhon Pathom and Samut Sakhon). The Condominium Price Index, Townhouse Pride Index, and Single detached house Price Index were compiled together into the index using the Rolling Window and Dummy Hedonic Regression method. The land was calculated into the index using the Stratification method with monthly weight. In this study, all 4 House Price Indexes will be used as conventional data.

2. Alternative indicators

- Apple Mobility Index

The Apple Mobility Index is a daily report of Driving and Walking index published by Apple. It shows the volume of direction lookup requests from Apple's Maps application by country/region, sub-region, or city. It is calculated compared to a baseline value, generated on 13 January 2020. The period of both Driving and Walking index used in this study is from January 13, 2020 to September 30, 2021, and the geographic location of the data used is Bangkok. All data are adjusted by using an average method to transform it into monthly data before using it in the study.

- COVID-19 infected Cases

The data of the number of COVID-19 infected cases in Thailand was obtained from the Ministry of Public Health, the date ranges from January 2020 to September 2021. The raw data acquired from the Ministry of Public Health is a daily level report, so a transformation was implemented to convert the daily level data to monthly level. This is done by taking the average value of each month. The reason the data had to be converted to monthly level is because the Conventional indicator or the Housing Price Index is a monthly level. And to connect the two datasets together, it needs to be in the same granularity, monthly data.

- Nighttime Light Index

The Nighttime Light Index data was retrieved from a map service application called www.lightpollutionmap.info. In this application, different satellite imaging data can be retrieved, including the Nighttime Light Index data that will be used in this study. For this study, the Nighttime Light Index data from January, 2020 to September 2021 is used to indicate House Price Index. The geographic boundary of the Nighttime Light Index collected is Bangkok Metropolis and Vicinities.

Methodology

- Ordinary Least Square Regression (OLS)

According to Encyclopedia (n.d.), Ordinary least squares (OLS) regression is an approximation model to analyze the relationship between dependent and independent variables by minimizing the sum of square differences between the observed and predicted values. This method is commonly known as Linear Regression.

OLS regression function:

$$Y = \beta_0 + \beta_1 X_i + \varepsilon$$

Where Y = Dependent variable

β_0 = Interception

β_1 = Coefficient

X_i = Independent variable

ε = Error term

- Apply Ordinary Least Square Regression (OLS) into study:

The log transformation method was used to normalize all data obtained first. Then, the Ordinary Least Square Regression can be applied into the study as

$$lnCMPI_t = \beta_0 + \beta_1 lnDriving_t + \varepsilon_t \quad (1)$$

$$lnCMPI_t = \beta_0 + \beta_2 lnWalking_t + \varepsilon_t \quad (2)$$

$$lnCMPI_t = \beta_0 + \beta_3 lnNTL_t + \varepsilon_t \quad (3)$$

$$lnCMPI_t = \beta_0 + \beta_4 lnX_{4t} + \varepsilon_t \quad (4)$$

$$lnTHPI_t = \beta_0 + \beta_1 lnDriving_t + \varepsilon_t \quad (5)$$

$$lnTHPI_t = \beta_0 + \beta_2 lnWalking_t + \varepsilon_t \quad (6)$$

$$lnTHPI_t = \beta_0 + \beta_3 lnNTL_t + \varepsilon_t \quad (7)$$

$$lnTHPI_t = \beta_0 + \beta_4 lnCOVID19\_case_t + \varepsilon_t \quad (8)$$

$$lnSHPI_t = \beta_0 + \beta_1 lnDriving_t + \varepsilon_t \quad (9)$$

$$lnSHPI_t = \beta_0 + \beta_2 lnWalking_t + \varepsilon_t \quad (10)$$

$$lnSHPI_t = \beta_0 + \beta_3 lnNTL_t + \varepsilon_t \quad (11)$$

$$lnSHPI_t = \beta_0 + \beta_4 lnlnCOVID19\_case_t + \varepsilon_t \quad (12)$$

$$lnLPI_t = \beta_0 + \beta_1 lnDriving_t + \varepsilon_t \quad (13)$$

$$lnLPI_t = \beta_0 + \beta_2 lnWalking_t + \varepsilon_t \quad (14)$$

$$lnLPI_t = \beta_0 + \beta_3 lnNTL_t + \varepsilon_t \quad (15)$$

$$lnLPI_t = \beta_0 + \beta_4 lnCOVID19\_case_t + \varepsilon_t \quad (16)$$

Where CMPI = Condominium Price Index

THPI = Townhouse Price Index

SHPI = Single detached House Price Index

LPI = Land Price Index

$Driving$ = Driving index from Apple Mobility Index

$Walking$ = Walking index Apple Mobility Index

NTL = Nighttime Light Index

$COVID19\_case$ = COVID-19 infected cases

ε_t = Error term

Result Analysis

There are 21 observations obtained from time series datasets ranging from January, 2020 to September, 2021. The result analysis is separated into 4 parts based on regression results on House Price Index including Condominium Price Index, Townhouse Price Index, Single detached House Price Index and Land Price Index.

1. Condominium Price index and Alternative indicators

The regression results of Condominium Price index and Alternative indicators are presented in Figure 1- 4 and Table 1 in Appendix. From Table 2, there is only one model that has a statistically significant P-value of less than 0.05 which is model 4. It is a model that uses nighttime Light Index as an alternative indicator to indicate the Condominium Price Index. However, this model has an R^2 value of 0.481 with adjusted R^2 value of 0.454. This implies that the Nighttime Light data can only partially explain the Condominium Price Index. Other alternative data should be used together with the Nighttime Light index inorder to get more accurate alternative indicators.

2. Townhouse Price Index and Alternative indicators

The regression results of Townhouse Price index and Alternative indicators are presented in Figure 5 - 8 and Table 2 in Appendix. From Table 2, there are three models that have statistically significant P-values of less than 0.05 which are model 6, 7, and 8. However, model 6 which explains about the relationship between Walking index and THPI has R^2 value of 0.465. So, it means that the Walking index has a low relationship with the THPI. For model 7, which is a model that explain the relationship between COVID-19 infected cases and THPI, there is a high R^2 value of 0.724 with the value of Adjusted R^2 of 0.71. This means that the number of COVID-19 infected cases is a good indicator to explain the THPI. COVID-19 infected cases can explain the THPI for 72.4%. When the number of infected cases increases by 1%, the THPI will increase by 0.003 %, holding other things constant. For model 8, it is a model that explains the relationship between Nighttime Light Index and THPI. This model has R^2 value of 0.639 which means that NTL also has a moderate relationship with THPI.

3. Single detached House Price Index and Alternative indicators

The regression results of Single detached House Price Index and Alternative indicators are presented in Figure 9 - 12 and Table 3 in Appendix. From Table 3, all models have statistically significant P-values of less than 0.05. However, both model 9 and 12 that are used to explain the relationship between Driving index and Nighttime Light Index on SHPI have R^2value lower than 0.5. This means that both Driving index and Nighttime Light Index have a low relationship with SHPI, and should not be used to explain SHPI. Model 10 which is used to explain the relationship between Walking index and SHPI, has the highest R^2 value of 0.805 with adjusted R^2 value of 0.794. This means that the Walking index has a strong relationship with SHPI and can be used to explain SHPI for 80.5%. When the Walking index increases by 1%, the SHPI will decrease by 0.0186%, holding other factors constant. For model 11, the number of COVID-19 infected cases can also partially explain SHPI as it has moderate R^2 value of 0.655.

4. Land Price Index and Alternative indicators

The regression results of Land Price Index and Alternative indicators are presented in Figure 13 - 16 and Table 4 in Appendix. From Table 4, all models have statistically significant P-values of less than 0.05. In this case, the Walking Index from model 14 is the best alternative indicator to explain the LPI because the regression result of this model has the highest R^2 value of 0.928 with adjusted R^2 value of 0.924. This means that the Walking index can explain the LPI for 942.4%. When the Walking index increases by 1%, LPI will decrease by 1.66%, holding other things constant. In addition, the results from Model 15 indicated that the number of COVID-19 infected cases can also moderately explain LPI because it has R^2 value of 0.622. However, model 13 and 16 which are Driving index and Nighttime Light Index should not be used to explain LPI as the R^2 values are 0.485 and 0.345 respectively. They have a low relationship with LPI.

Policy Recommendations

- Use these alternative data mention in this studied to indicate the House Price Index

Based on this study, as alternative data can be used to explain the House Price Index, the Government should consider the use of alternative indicators to predict the House Price Index during the COVID-19 pandemic as well as using these data to predict the House Price Index after the COVID-19 pandemic. Government should study more on the reasons for these relationships as well in order to understand more about people's behavior.

- Strengthen the use of Land and Building Tax

The government should increase the tax collection amount for the lands and buildings tax instead. However, the lands and buildings value criteria for tax collection need to stay the same. This means that the government will be able to collect more land and buildings tax from the higher income people. This will result in the higher income people being able to help contribute to the development of societies and communities during this Covid-19 pandemic. Moreover, by doing this, the demand for houses of high income people will be decreased. Therefore, the housing price will also decrease. This is an indirect way to slow down the price of houses so that lower income people can buy the house.

- Promote the development of non CBD area

The government should see the COVID-19 pandemic as an opportunity to expand to urban development. Many people moved out from the CBD area because they can work from their home. By moving out of the CBD areas, they can save some cost spending on rental. Therefore, the non CBD area should be developed to decentralize the city. Moreover, rural areas and suburban areas should also be promoted as well. By developing the non CBD areas, the demand for real estates in the CBD areas will slowly decrease over time.

Conclusion

In Conclusion, during the COVID-19 pandemic, all of the House Price Indexes except Condominium Price index can be successfully predicted with the alternative indicators. For the Townhouse Price Index, the best alternative indicator is the number of COVID-19 infected cases. For the Single detached House Price Index and Land Price Index, the Walking index is the best indicator to explain them. The Condominium Price index on the other hand can only be slightly predicted using the Nighttime Light index. However, compared to the rest of the predictions of House Price Indexes, it still has a very low relationship with CMPI as the value of R^2 is low. Therefore, it should not be used in explaining the CMPI.

Limitations and suggestions on further study

- Increase the number of observations

Because the COVID-19 pandemic first came to Thailand in January, 2020, there are a limited number of observations, n=21, which may cause bias to the study. Therefore, more observations should be used in order to increase the accuracy rate of the study.

- Apply more complex models into the study

This study uses only simple linear regression to see the relationship between conventional indicators and alternative indicators. Therefore, there is a room for further study to use more complex models to study the relationship between conventional data and alternative data such as Multiple regression.

- Add more alternative data sources

This study uses 3 sources of alternative data which are Apple Mobility Index, COVID-19 infected case, and Nighttime light index, so there is also interesting data left to be investigated such as Google Mobility Index.

Bibliography

Ahmed, D. E. E. A. (2020). Impact of Macroeconomic Variables on Housing Prices in Saudi Arabia: A VAR Approach. *Creative Commons Attribution License*. Published. https://doi.org/10.20944/preprints202012.0715.v1

Brueckner, J., Kahn, M., & Lin, G. (2021). A NEW SPATIAL HEDONIC EQUILIBRIUM IN THE EMERGING WORK-FROM-HOME ECONOMY? *NBER WORKING PAPER SERIES*. Published. https://www.nber.org/system/files/working_papers/w28526/w28526.pdf

Coccia, M. (2021). The relation between length of lockdown, numbers of infected people and deaths of Covid-19, and economic growth of countries: Lessons learned to cope with future pandemics similar to Covid-19 and to constrain the deterioration of the economic system. *Science of The Total Environment*, *775*, 145801. https://doi.org/10.1016/j.scitotenv.2021.145801

COVID-19. (n.d.). Department of Disease Control. Retrieved December 15, 2021, from https://ddc.moph.go.th/viralpneumonia/

COVID - 19 - Mobility Trends Reports. (n.d.). Apple. Retrieved December 15, 2021, from https://covid19.apple.com/mobility

Hepşen, A., & Vatansever, M. (2012). RELATIONSHIP BETWEEN RESIDENTIAL PROPERTY PRICE INDEX AND MACROECONOMIC INDICATORS IN DUBAI HOUSING MARKET / SANTYKIS TARP GYVENAMOJO NT INDEKSO IR MAKROEKONOMINIŲ RODIKLIŲ DUBAJAUS BŪSTO RINKOJE. *International Journal of Strategic Property Management*, *16*(1), 71–84. https://doi.org/10.3846/1648715x.2011.602756

I. (2021, October 18). *Housing Prices Continue to Soar in Many Countries Around the World*. IMF Blog. https://blogs.imf.org/2021/10/18/housing-prices-continue-to-soar-in-many-countries-around-the-world/

Jones, B. D. P. L. D. B. (2021, January 24). *Coronavirus: How the pandemic has changed the world economy*. BBC News. https://www.bbc.com/news/business-51706225#:%7E:text=Most%20of%20countries%20now%20in%20recession&text=The%20IMF%20estimates%20that%20the,grow%20in%202020%20was%20China.&text=The%20IMF%20is%2C%20however%2C%20predicting,growth%20of%205.2%25%20in%202021.

Light pollution map. (n.d.). Light Pollution Map. Retrieved December 15, 2021, from https://www.lightpollutionmap.info/

Limpanasukhon, K. (2015). The Relation among Economic Factors and the Impact on Property Price Index in Thailand. *BU*. Published. http://dspace.bu.ac.th/bitstream/123456789/1822/1/kriengkrai.limp.pdf

Measuring the Economics of a Pandemic: How People Mobility Depict Economics? Evidence of People's Mobility Data towards Economic Activities. (2021). *IMF*. Published. https://www.imf.org/-/media/Files/Conferences/2020/8th-stats-forum/paper-rendra-putra-and-silvia-arini.ashx

Ordinary Least Squares Regression | Encyclopedia.com. (n.d.). Encyclopedia. Retrieved December 15, 2021, from https://www.encyclopedia.com/social-sciences/applied-and-social-sciences-magazines/ordinary-least-squares-regression

Roberts, M. (2021). Tracking economic activity in response to the COVID-19 crisis using nighttime lights – The case of Morocco. *Development Engineering*, *6*, 100067. https://doi.org/10.1016/j.deveng.2021.100067

Satirapipatkul, P. (2021). Adaptation Strategies to COVID-19 Impact on Business of the Set- Registered Real Estate Development Companies in 2020. *Department of Housing, Faculty of Architecture, Chulalongkorn University*. Published. https://so05.tci-thaijo.org/index.php/sarasatr/article/view/251318

Singlor, T. (2021, October 29). *Global Housing Watch by IMF ชี้ ราคาที่อยู่อาศัยยังคงพุ่งสูงขึ้นในหลายประเทศ*. SDG Move. https://www.sdgmove.com/2021/10/29/unaffordable-homes-as-housing-prices-rise-in-many-countries/

Sun, Y., Wang, S., Zhang, X., Chan, T. O., & Wu, W. (2021). Estimating local-scale domestic electricity energy consumption using demographic, nighttime light imagery and Twitter data. *Energy*, *226*, 120351. https://doi.org/10.1016/j.energy.2021.120351

Tourism analysis by using High-Frequency Indicators. (2020). *Krungsri*. Published. https://krungthai.com/Download/economyresources/EconomyResourcesDownload_574Research_Note_07_07_63.pdf

Wang, X. (2016). Interest rates and housing prices: A cross comparison between the US and China. *The Faculty Supervision of Professor Colin Ward, in Partial Fulfillment of the Requirements for the Bachelor of Science in Business, Magna Cum Laude, Carlson School of Management, University of Minnesota,*. Published. https://conservancy.umn.edu/bitstream/handle/11299/184898/Xinyang%20Wang%20magna%20CSOM%20fall2016.pdf?sequence=1

Yusof, A., & Ismail, S. (2012). Multiple Regressions in Analysing House Price Variations. *Communications of the IBIMA*, 1–9. https://doi.org/10.5171/2012.383101

Zhang, Q. (2021). Housing Price Prediction Based on Multiple Linear Regression. *Scientific Programming*, *2021*, 1–9. https://doi.org/10.1155/2021/7678931

Appendix

Part 1: Figure

Figure 1: Relationship between Condominium Price Index and Apple Mobility Index (Driving)

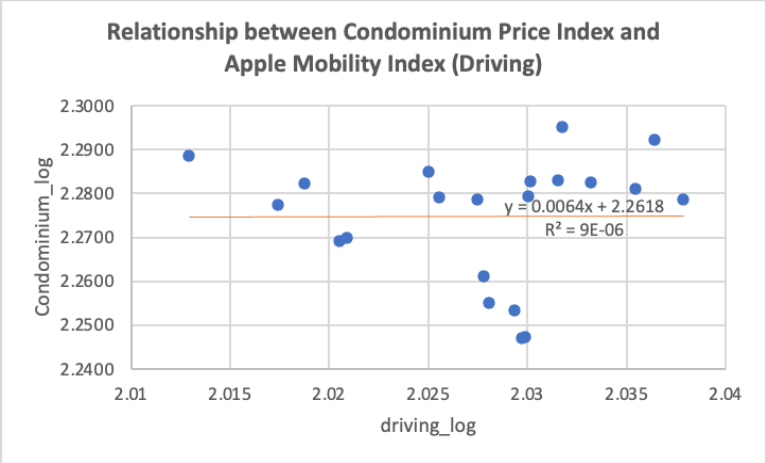


Figure 2: Relationship between Condominium Price Index and Apple Mobility Index (Walking)

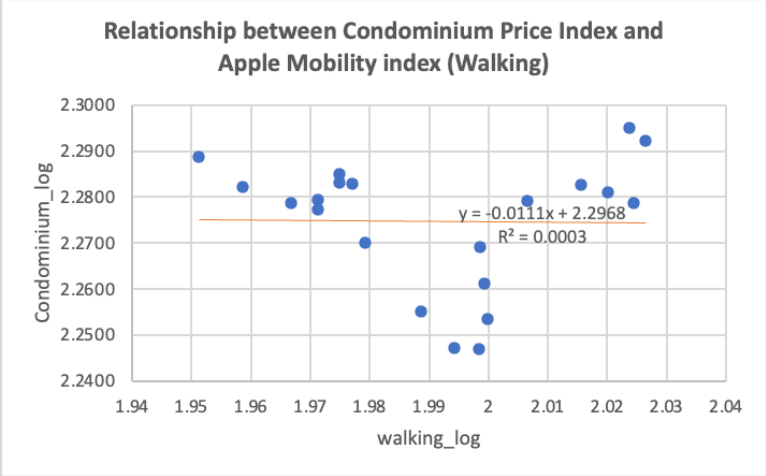


Figure 3: Relationship between Condominium Price Index and COVID-19 infected Case

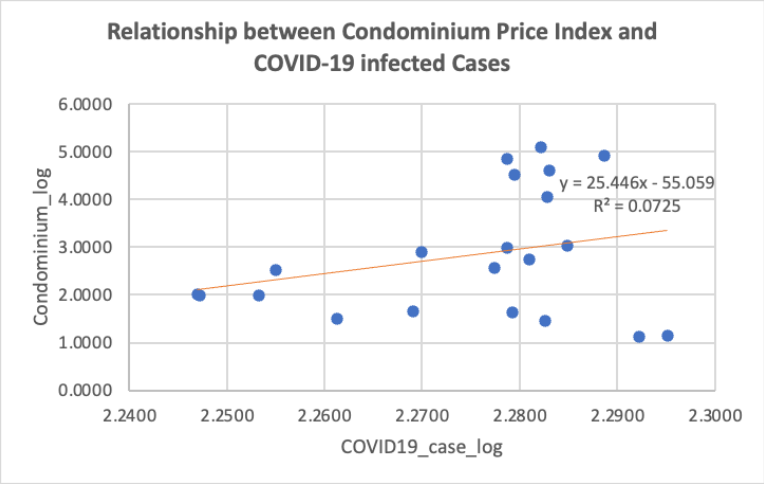


Figure 4: Relationship between Condominium Price Index and Nighttime Light Index

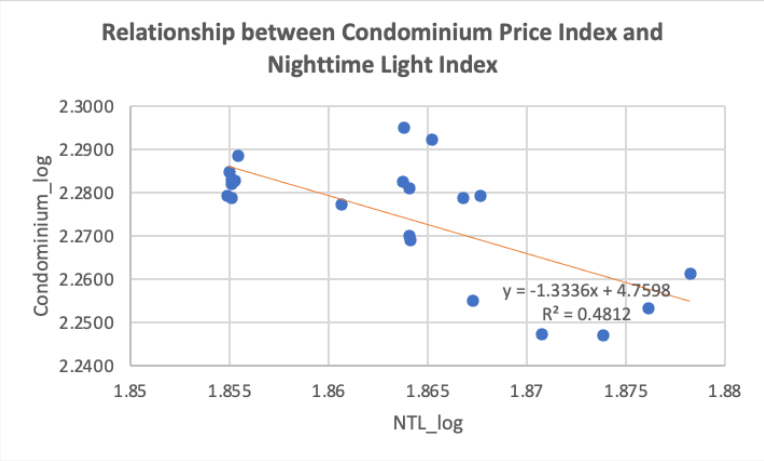


Figure 5: Relationship between Townhouse Price Index and Apple Mobility Index (Driving)

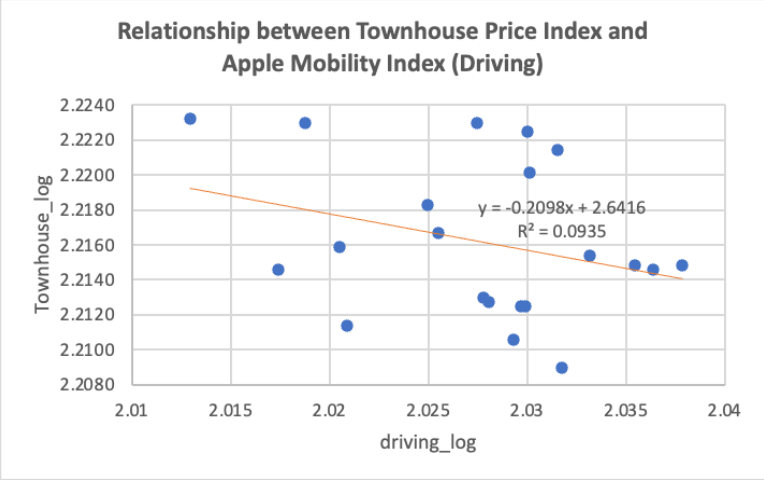


Figure 6: Relationship between Townhouse Price Index and Apple Mobility Index (Walking)

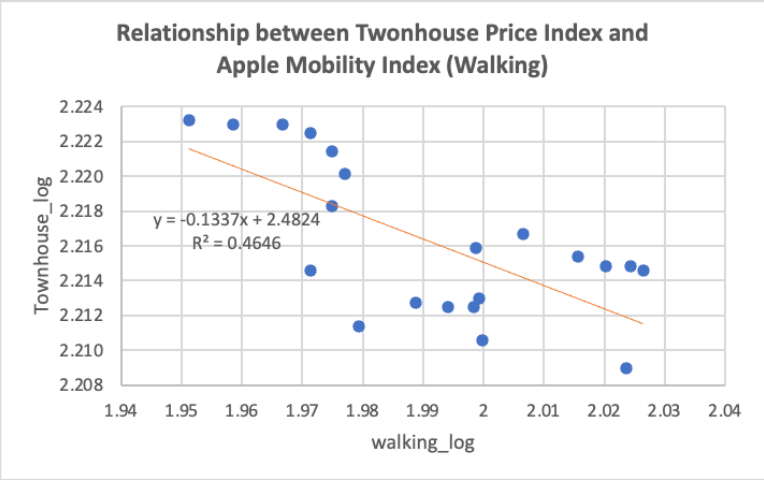


Figure 7: Relationship between Townhouse Price Index and COVID-19 infected Cases

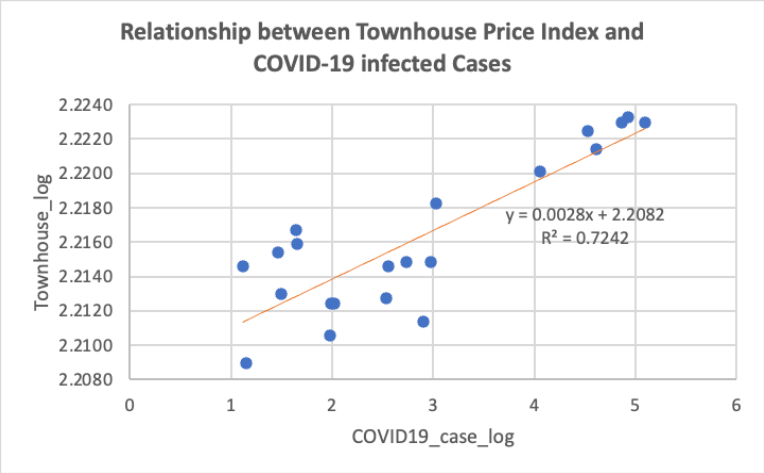


Figure 8: Relationship between Townhouse Price Index and Nighttime Light Index

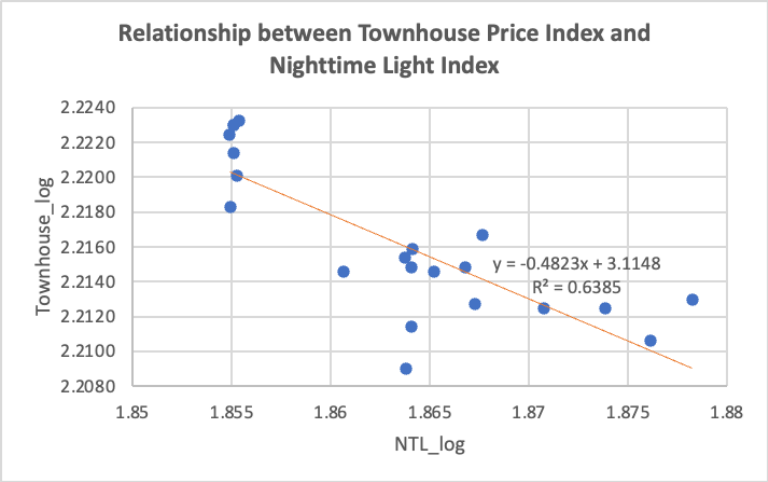


Figure 9: Relationship between Single detached house Price Index and Apple Mobility Index (Driving)

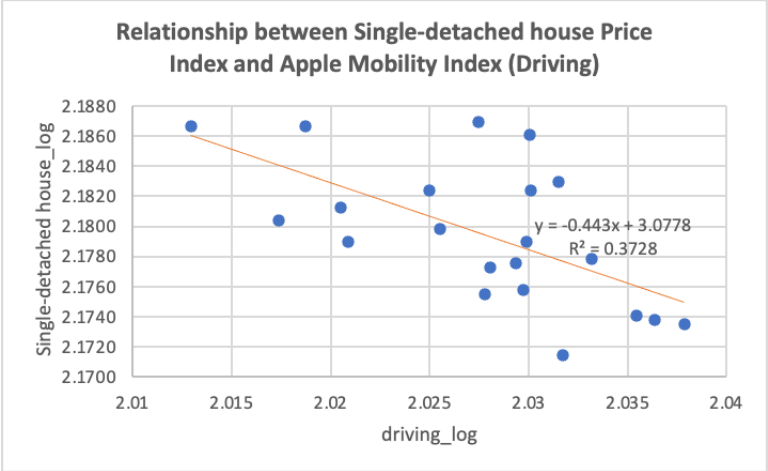


Figure 10: Relationship between Single detached house Price Index and Apple Mobility index (Walking)

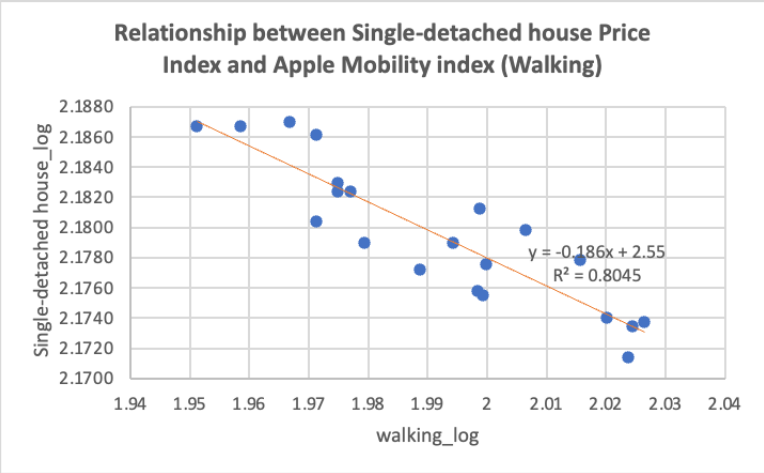


Figure 11:Relationship between Single detached house Price Index and COVID-19 infected Cases

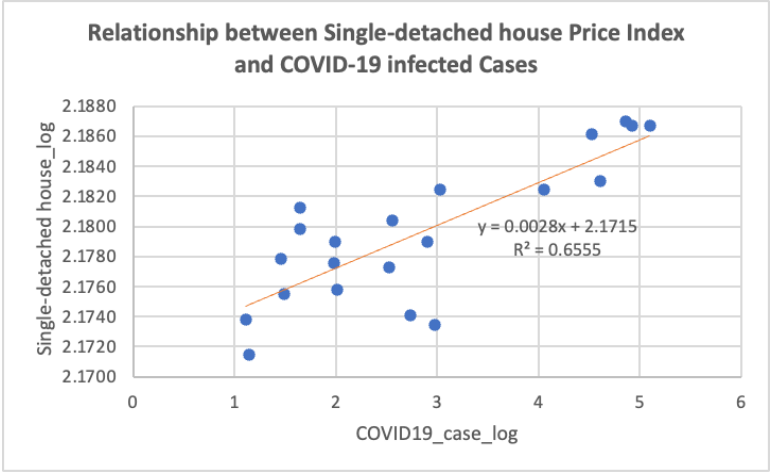


Figure 12: Relationship between Single detached house Price Index and Nighttime Light Index

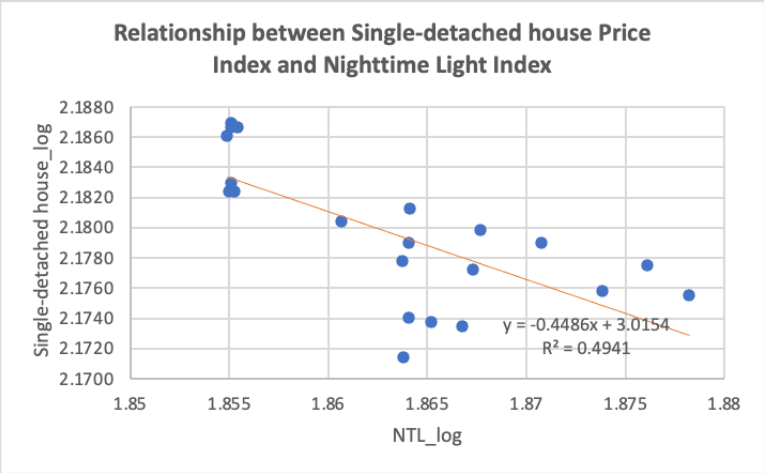


Figure 13: Relationship between Land Price Index and Apple Mobility Index (Driving)

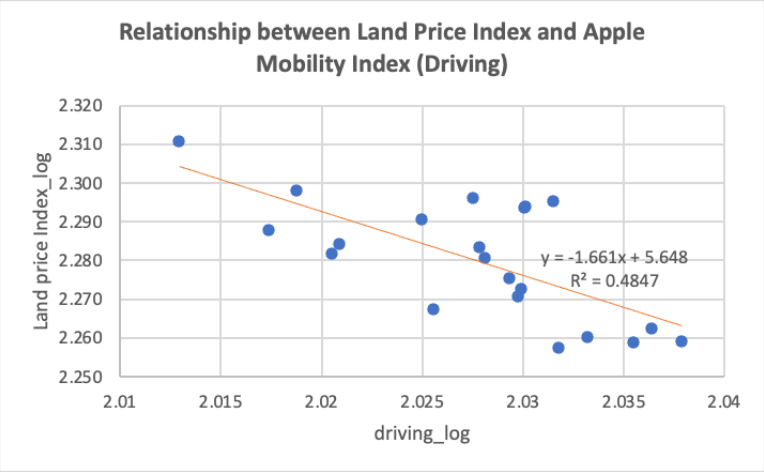


Figure 14: Relationship between Land Price Index and Apple Mobility Index (Walking)

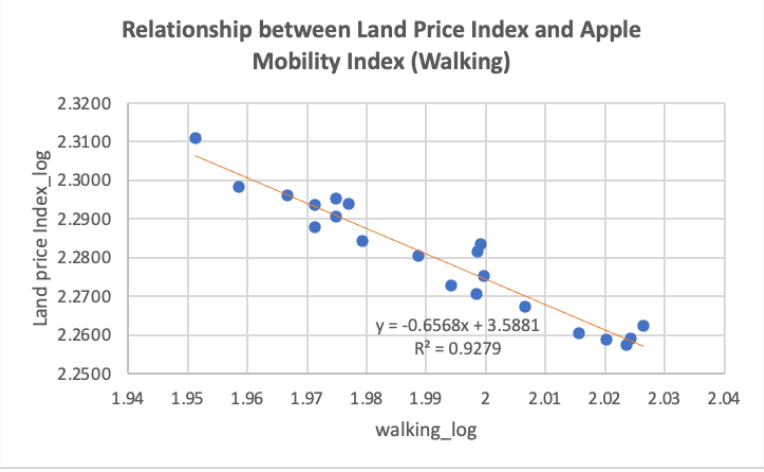


Figure 15: Relationship between Land Price Index and COVID-19 infected cases

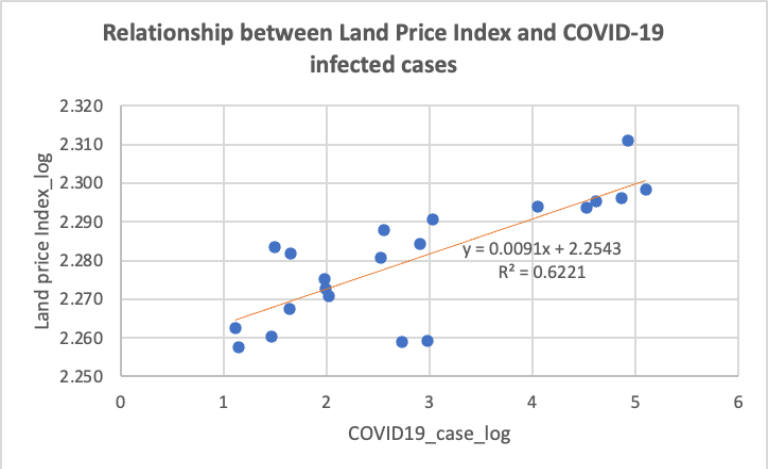
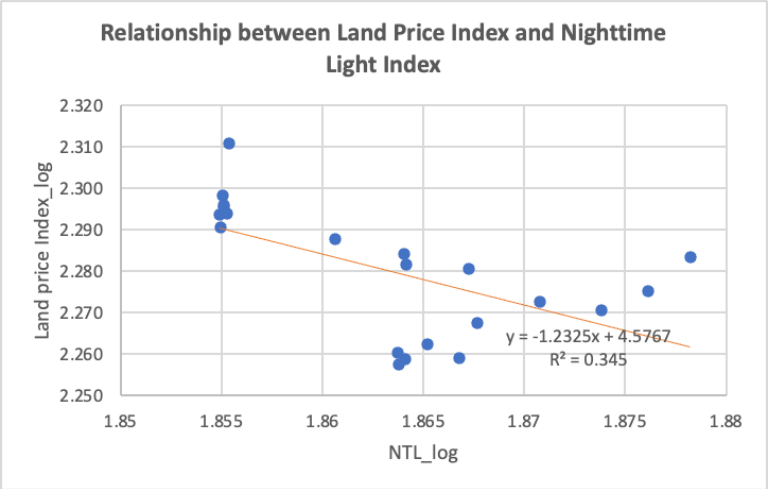


Figure 16: Relationship between Land Price Index and Nighttime Light Index



Part 2: Table

Table 1: Regression result between Condominium Price Index and Alternative indicators

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*	*Regression Statistics*	
Intercept	2.26178966	1.01685574	2.224297478	0.038446727	0.133486135	4.390093184	0.133486135	4.390093184	R Square	8.511E-06
driving_log	0.0063774	0.501504414	0.012716539	0.989986523	-1.043283402	1.056038202	-1.043283402	1.056038202	Adjusted R Square	-0.05262262
Intercept	2.29679637	0.285410109	8.047354642	1.53512E-07	1.699426145	2.894166593	1.699426145	2.894166593	R Square	0.000314819
walking_log	-0.01108521	0.143307262	-0.077352713	0.939151737	-0.311030752	0.288860341	-0.311030752	0.288860341	Adjusted R Square	-0.052300191
Intercept	2.2666736	0.007273948	311.615323	1.0604E-36	2.25144906	2.28189815	2.25144906	2.28189815	R Square	0.07249127
COVID19_case_log	0.00284878	0.002337749	1.21859858	0.23791173	-0.0020442	0.00774174	-0.0020442	0.00774174	Adjusted R Square	0.02367503
Intercept	4.75982275	0.591957303	8.040821061	1.5538E-07	3.520841874	5.998803622	3.520841874	5.998803622	R Square	0.481220098
NTL_log	-1.33361846	0.317668746	-4.198141844	0.000487378	-1.998506785	-0.668730129	-1.998506785	-0.668730129	Adjusted R Square	0.453915893

Table 2: Regression result between Townhouse Price Index and Alternative indicators

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*	*Regression Statistics*	
Intercept	2.641649099	0.303936218	8.69145874	4.78905E-08	2.005503283	3.277794914	2.005503283	3.277794914	R Square	0.09349491
driving_log	-0.209837712	0.149898701	-1.399863442	0.177671057	-0.5235793	0.103903876	-0.5235793	0.103903876	Adjusted R Square	0.04578412
Intercept	2.482406784	0.065573151	37.85706131	2.33597E-19	2.345160602	2.619652966	2.345160602	2.619652966	R Square	0.46456794
walking_log	-0.133682368	0.032924933	-4.060216871	0.000667736	-0.202595044	-0.064769691	-0.202595044	-0.064769691	Adjusted R Square	0.4363873
Intercept	2.208197231	0.001245137	1773.457556	4.75764E-51	2.20559113	2.210803332	2.20559113	2.210803332	R Square	0.72423479
COVID19_case_log	0.002826777	0.00040017	7.063935895	1.01032E-06	0.001989211	0.003664342	0.001989211	0.003664342	Adjusted R Square	0.70972083
Intercept	3.114832084	0.155126563	20.07929541	2.96368E-14	2.790148456	3.439515711	2.790148456	3.439515711	R Square	0.63850488
NTL_log	-0.482256366	0.083247323	-5.793055543	1.39693E-05	-0.656495015	-0.308017716	-0.656495015	-0.308017716	Adjusted R Square	0.61947882

Table 3: Regression result between Single detached House Price Index and Alternative indicators

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*	*Regression Statistics*	
Intercept	3.07779384	0.267298286	11.51445409	5.18803E-10	2.518332098	3.637255582	2.518332098	3.637255582	R Square	0.37279211
driving_log	-0.443012506	0.131829192	-3.360503849	0.003285004	-0.718934174	-0.167090837	-0.718934174	-0.167090837	Adjusted R Square	0.33978117
Intercept	2.549951311	0.041891817	60.86991402	3.02873E-23	2.462270729	2.637631892	2.462270729	2.637631892	R Square	0.80451002
walking_log	-0.185998021	0.021034299	-8.842606056	3.6717E-08	-0.230023315	-0.141972727	-0.230023315	-0.141972727	Adjusted R Square	0.79422107
Intercept	2.171509908	0.001471481	1475.73091	1.56257E-49	2.168430063	2.174589753	2.168430063	2.174589753	R Square	0.65546886
COVID19_case_log	0.002843288	0.000472914	6.012271675	8.74843E-06	0.001853468	0.003833109	0.001853468	0.003833109	Adjusted R Square	0.63733565
Intercept	3.015385895	0.194018993	15.54170472	2.94415E-12	2.609299476	3.421472314	2.609299476	3.421472314	R Square	0.49413757
NTL_log	-0.448552086	0.104118608	-4.308087631	0.000379324	-0.666474837	-0.230629336	-0.666474837	-0.230629336	Adjusted R Square	0.46751324

Table 4: Regression result between Land Price Index and Alternative indicators

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*	Regression Statistics	
Intercept	5.647952535	0.796711618	7.08908017	9.61242E-07	3.980415954	7.315489117	3.980415954	7.315489117	R Square	0.48467605
driving_log	-1.66103576	0.392931246	-4.227293644	0.000456024	-2.48345031	-0.83862121	-2.48345031	-0.83862121	Adjusted R Square	0.457553736
Intercept	3.588126735	0.083657399	42.89072779	2.23733E-20	3.413029787	3.763223684	3.413029787	3.763223684	R Square	0.927900263
walking_log	-0.656846386	0.042005214	-15.63725829	2.64166E-12	-0.74476431	-0.568928462	-0.74476431	-0.568928462	Adjusted R Square	0.92410554
Intercept	2.254307295	0.00506785	444.8251607	1.22754E-39	2.243700163	2.264914428	2.243700163	2.264914428	R Square	0.622057619
COVID19_case_log	0.009108162	0.001628739	5.59215641	2.15598E-05	0.005699173	0.012517152	0.005699173	0.012517152	Adjusted R Square	0.602165915
Intercept	4.576694951	0.725957777	6.304354187	4.73386E-06	3.057247861	6.096142041	3.057247861	6.096142041	R Square	0.345023809
NTL_log	-1.23249182	0.389578937	-3.163651064	0.005113998	-2.047889907	-0.417093733	-2.047889907	-0.417093733	Adjusted R Square	0.310551378