Does the Alonso-Muth-Mills Model Hold True After the 2020 Pandemic?

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Abstract

In conjunction with the standard Alonso-Muth-Mills model, city centers and their urban surroundings have been the most desirable place to live. In 2020 the pandemic created the opportunity for workers to work from home. I conduct an empirical study in the 60 largest cities in the United States to test whether the possibility of working from home does not only imply a restructure in labor dynamics, but also in real estate markets, and the spatial distribution of cities. I find that with the possibility of working from home, home buyers undergo a shift in home preferences that to an extent favors homes farther away from central business districts, where more spacious homes are cheaper.

Introduction

The standard Alonso-Muth-Mills model, assumes a city with a fixed population and a given income level centered around a central business district (CBD). Most workers travel into the CBD for work, however, the cost of commuting increases with farther distance from the CBD. Hence, households will choose, other things equal, to live closer to the city center.[1] Thus, the model predicts higher housing demand closer to the CBD, and thereby higher prices per home area. Although the model has lost much of its predictive power as many cities have increasingly become

[1] Alonso, *Location and Land Use: Toward a General Theory of Land Rent*.

more polycentric; yet, the model developed in 1970 and its predictive theory have been able to withstand the test of time.[2]

In 2020, with the pandemic, households and businesses redesigned the working paradigm induced by stay at home restrictions and safety protocols. Thus, there begins a successful natural experiment that shows the efficacy of working from home (WFH). The successful experiment does not only offer a benefit to employers, workers are suddenly able to work from wherever they want and liberate from their everyday work commutes. Given these conditions, I hypothesis that many households are compelled towards moving farther away from the central business district. Hence, this societal change presents an inconsistency with the underlying assumptions from the standard Alonso-Muth-Mills model, where workers have a strong preference for allocating closer towards a CBD. I look to test the hypothesis on whether the pandemic imposed a divergence in housing demand from the CBD towards the periphery by running an empirical study.

My study relates to the growing literature on real estate markets coupled with Covid and WFH. (Delventhal, Kwon, and Parkhomenko 2020) investigates whether WFH should affect the spatial redistribution of cities. Their research only focuses on the city of Los Angles, and it finds supportive evidence for a divergence towards the suburban areas in the city of Los Angeles.[3] This body of research is subsequently expanded in (Liu and Su 2021) and then developed even further in (Ramani and Bloom 2021).

In (Liu and Su 2021), this body of research expands onto the largest 25 metropolitan statistical areas in the United. States. The study is based on three categories, which are based on radii proximity to the city center and compare the monthly average rate of change with the pre-

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[2] Spivey, "The Mills—Muth Model of Urban Spatial Structure."

[3] Delventhal, Kwon, and Parkhomenko, "How Do Cities Change When We Work from Home?"

pandemic average. The researchers mainly find that that the pandemic has led to a shift in housing demand away from neighborhoods with high population density.[4] Subsequently, (Ramani and Bloom 2021) expands this body of research by quantifying migration patterns across the largest 365 cities. They find that real estate demand does in fact move from CBD's towards lower density suburban zip codes, resembling a "Donut Effect", that reflects movement from city centers towards suburban rings. The research finds that the donut effect is most evident in the largest populated cities.[5]

My study looks at expanding this body of research by generating a new model that is constituted by characteristics from the models used for (Liu and Su 2021) and (Ramani and Bloom 2021). Furthermore, my model differs in how I control for economic indicators that measure general economic state as well as the feasibility that workers can indeed work from home. Moreover, my research provides more recent data that helps us better analyze whether a long-term dynamic is present.

2. Data Description

This study focuses only on the 60 most populated cities in the United States. To measure the divergence from the CBD towards the suburban areas, for each city or conurbation, I created three categories: category one consists of all the zip codes whose geographic center falls within a 0-5-mile radius from the CBD, group 2 is those that fall within a 5-10 miles radius from the CBD, and group 3 is 10-15 miles. I used the cities' town hall coordinates since it is within the best two reference points that best approximates CBDs.[6] The total number of zip codes grouped were 3414.

[4] Liu and Su, "The Impact of the COVID-19 Pandemic on the Demand for Density."
[5] Ramani and Bloom, "The Donut Effect of Covid-19 on Cities."
[6] "Where Is the City's Center?"

My final data set is thus a panel data composed by monthly observations and zip codes, ranging from January 2018 until September 2021. The total number of observations in the data set was 113,619 but for the model only 88,233 were used. The response variable is housing prices (ZHVI) and the explanatory and control variables are unemployment rate, GDP, consumer price index, and new covid cases.

2.1 Response Variable: Housing Prices (ZHVI)

To measure the general housing prices within a zip code I used Zillow's ZHVI, it reflects the typical value for homes in the 35th to 65th percentile range. This data was gathered from the bridge data API. Data was only available for 2082 zip codes out of the original 3414 that belonged to the three radii group. From the available data, 629 out of 939 zip codes belong to radius group 1, 793 out of 1293 zip codes belong to radius group 2, and 660 out of 1181 zip codes belong to radius group 3; that is, 67%, 61%, and 56%, respectively.

2.2 Control and Explanatory Variables

In order to control for the general price level increase, I decided to use the consumer price index (CPI). The unemployment rate was used as a proxy for determining places that had a better likelihood that a worker there could be able to work from home. That is, lower unemployment rate means more workers and hence, on average, more workers that can work from home. Gross Domestic Product (GDP) was used as to control for the current economic state. All these three variables were gathered from the federal reserve of economic data (FRED). The data is not available by zip code and thus, it was matched based on the state at which the zip code lies. As for

GDP, monthly data was not available, I decided to use the quarter level data and converted it into monthly level data by assuming a linear relationship between quarters.

A sound conjecture for why people could be moving is local covid cases and hence, I controlled for new covid cases. This data was retrieved from the COVID19 data repository by the University of Oxford. Once again, this data was not available at the zip code level, however, it was matched based on the city at which a zip code resides.

2.3 Data Conclusion

The projected data set from the original 3,414 identified zip codes could have induced a more robust analysis. I note that the reason for the missing 1,332 zip codes is not known. Then, from the 113,619 observation only 88,233 were used for the model. This was due to missing values when matching variables that were gathered from different sources. I note that these missing values are possibly non-random and thus could induce a bias in the model. Another soft spot in my data is the spatial non-precise matching of variables. Certainly, had all the variables been at the zip code level, my analysis would have been more precise. Nonetheless, the data used for my analysis comes from reliable sources and indeed having zip code level data is a plus given its scarcity. And 88,233 observations still make up a myriad of data for any kind of analysis.

3. Model

The model used for my analysis is:

$$home = \beta_0 + \beta_1 time + \beta_2 dist(5\ \ to\ 10) + \beta_3 dist(10\ \ to\ 15) + \beta_4 wfh$$
$$+ \beta_5 gdp + \beta_6 ur + \beta_7 cpi + \beta_8 covid + \beta_9 dist(5\ \ to\ 10) * wfh$$
$$+ \beta_{10} dist(10\ \ to\ 15) * wfh + u$$

The model used is ordinary least squares with three iterations from weighted least squares, used as a remedial measure for non-constant variance of the error term.

The table below includes coefficients and significance level. For table with standard errors and confidence intervals please refer to appendix B.

	home	
Predictors	*Estimates*	*p*
(Intercept)	-1064849.18	**<0.001**
time	-260.41	**<0.001**
dist [5-10 miles]	11194.24	**0.002**
dist [10-15 miles]	24757.17	**<0.001**
wfh [1]	-87979.94	**<0.001**
gdp	0.17	**<0.001**
ur	15156.73	**<0.001**
cpi	23241.03	**<0.001**
covid_cases	0.17	**<0.001**
dist [5-10 miles] * wfh [1]	55622.90	**<0.001**
dist [10-15 miles] * wfh [1]	20565.46	**<0.001**
Observations	88233	
R^2 / R^2 adjusted	0.155 / 0.155	

I included time as a control variable in order to control for seasonal variations in home prices. The variable coded "wfh" is a dummy variable that represents a time break. The variable wfh is one for observations after April 2020, the date that best represents when most states had declared lockdown and thereby, most workers have had to begin working from home.[7]

What was most surprising about the model was the coefficients for the (5 to 10) miles and (10 to 15) miles. Since both of these coefficients represent the mean difference between that category and the reference group, (0 to 5) miles, taking the assumptions from the standard Alonso-Muth-Mills, I expected a negative coefficient. Presumably, one reason for this is that my model does not account for price per area. Therefore, the result for why houses farther away from the CBD are more expensive on average may be due to the omitted factor housing size.

Nonetheless, the variables of interest for my analysis were the interactions between distance and working from home. The positive coefficients for both groups display the story underlined by my hypothesis but one again, the omitted factor housing size could play a key role in this result. Although, the (5 to 10) mile group and wfh interaction coefficient is substantially higher in magnitude in contrast with its lower order term, this comparison better indicates that there is an increase in demand as a result of WFH. However, this contrast is not seen in the (10 to 15) mile group.

4. Conclusion

I find that the theory from the standard Alonso-Muth-Mills model is contradicted by the outward divergence in population induced by the pandemic and WFH. My research finds that the

[7] "Coronavirus."

increase in housing demand is seen within 5 to 10 miles from the CBD but not within 10 to 15 miles from the CBD.

This effect mainly concerns local governments. It is important for local governments to track housing demand induced by the pandemic so that they are aware of where wealthy people are taking their money. Since higher earning jobs are also the most likely to permit workers to work from home and therefore it can be implied that most people who are engaging in the current housing reallocation trend are the ones with better salaries. This will happen because of the positive correlation between the highest paying jobs, and the likelihood that those jobs permit workers to work from home.[8] Another concern may be for consumers, since places where home prices had previously been affordable and stable might incur a disproportionate price surge.

Although I have highlighted the lurking problems that we might be facing with the ongoing population divergence, I think that more time needs to pass so that we can better understand the implications from the post pandemic and WFH induced city divergence. Also, I want to encourage that future research is done that not only involves updated data but also looks at including omitted variables that contribute to our understanding in this body of research.

Appendix A

Summary Statistics

Variable	*Mean*	*SD*	*Median*	*Min*	*Max*	*Skew*
zhvi(home)	478,422.85	454720.86	33741	21174	11,516,658	3.77

[8] Dingel and Neiman, "How Many Jobs Can Be Done at Home?"

ur	5.99	3.32	4.40	2.00	29.50	1.92
covid_cases	15,044.22	111902	0	0	1,459,891	10.55
cpi	258.54	6.95	257.3	248.7	274.1	0.77
gdp	1,216,006	1051712	661572	0	3,290,170	0.79

Mean inter-item-correlation=0.124 · Cronbach's α=0.306

Appendix B

Regression Coefficient Statistics

	zhvi			
Predictors	*Estimates*	*std. Error*	*95% CI*	*p*
(Intercept)	-1064849.18	103339.60	-1267,393.86 – -862,304.50	**<0.001**
date	-260.41	10.83	-281.65 – -239.18	**<0.001**
dist [10 miles]	11194.24	3558.45	4,219.72 – 18,168.76	**0.002**
dist [15 miles]	24757.17	3763.75	17,380.25 – 32,134.08	**<0.001**
wfh [1]	-87979.94	6240.95	-100,212.15 – -75,747.72	**<0.001**
gdp	0.17	0.00	0.17 – 0.17	**<0.001**
ur	15156.73	589.18	14,001.94 – 16,311.52	**<0.001**
cpi	23241.03	574.50	22,115.01 – 24,367.06	**<0.001**
confirmed	0.17	0.01	0.15 – 0.20	**<0.001**
dist [10 miles] * wfh [1]	55622.90	5435.34	44,969.69 – 66,276.11	**<0.001**
dist [15 miles] * wfh [1]	20565.46	5344.17	10090.95 – 31039.98	**<0.001**
Observations	88233			
R^2 / R^2 adjusted	0.155 / 0.155			

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