Assessing the Impact of Amazon Fulfillment Centers on PM2.5 Levels in Surrounding Areas

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I. Overview and Student Role

This study investigates the impact of Amazon's fulfillment centers on surrounding areas' fine particulate matter (PM2.5) levels. We used the synthetic controls with staggered adoption method and included the Rural-Urban Commuting Area Codes (RUCC) score as an auxiliary covariate. Our analysis indicates that Amazon's fulfillment centers have a positive effect on PM2.5 levels in surrounding areas, with an average estimated ATT of 0.098. The effect varies across years, with most years showing a positive effect. Furthermore, we found that the effect is concentrated in areas with a lower RUCC score. Our results have implications for policymakers and companies alike, highlighting the importance of considering the environmental impact of industrial activities in surrounding communities.

As the only student in this project, I collected and cleaned the data, wrote the R code, and analyzed the results under the supervision of Professor Rudolph. This research contributes to the literature on the impact of e-commerce and warehousing on air quality and can inform policy decisions related to the siting of fulfillment centers in urban areas.

II. Background

The rapid growth of e-commerce has led to an increase in warehouse construction to meet the demand for online shopping. These warehouses, including Amazon's fulfillment centers, are often located in urban areas and serve customers scattered throughout the region.

Consumer goods are purchased online and then delivered to consumers, where the last leg of delivery typically involves ground transportation via delivery trucks. However, Vehicle exhaust is a significant source of ambient PM2.5[1, 2]. PM2.5 is a common air pollutant that has been associated with multiple adverse health outcomes[3]. Previous studies have shown increased risk of respiratory and cardiovascular disease associated with close residential proximity to traffic pollution[4, 5].

The operation of Amazon's fulfillment centers may increase the level of PM2.5 in surrounding areas, leading to negative health impacts for nearby residents. However, there is limited research on the specific impact of Amazon's fulfillment centers on PM2.5 levels in surrounding areas.

Given the potential environmental and health impacts of Amazon's fulfillment centers, it is crucial to assess their impact on air quality to ensure the well-being of local communities and the environment. This study aims to contribute to the existing literature on the impact of e-commerce and warehousing on air quality and inform policy decisions related to the siting of fulfillment centers in urban areas.

III. Methods

A. Data

(1) Surface PM2.5

The PM2.5 level dataset is downloaded from the Atmospheric Composition Analysis Group at Washington University in St. Louis website. The original reference is here[6].

(2) Amazon Fulfillment Centers Address Data

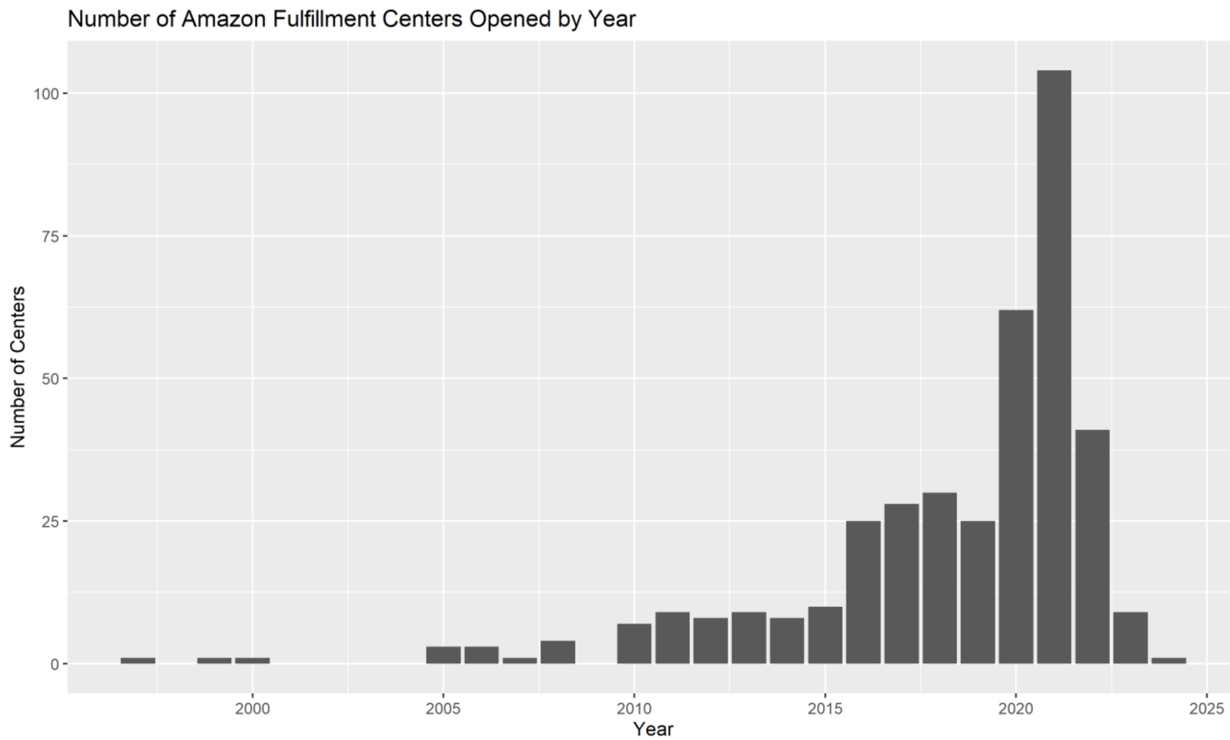
From open-source data.

(3) Rural-Urban Continuum Codes (2013)

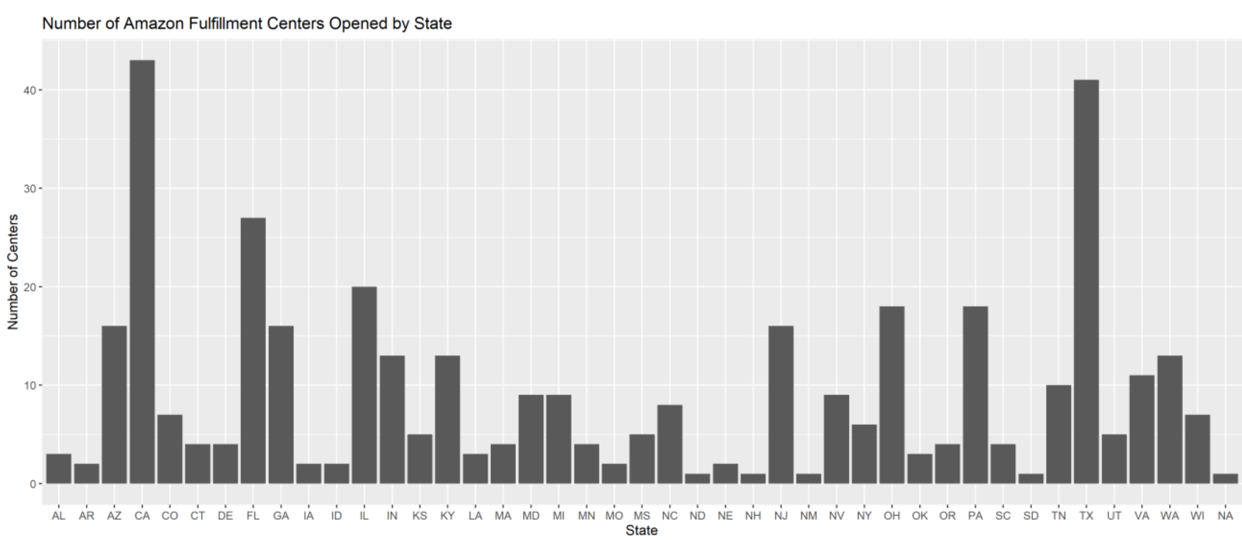
The RUCC dataset is downloaded from the website of Economic Research Service, U.S. DEPARTMENT OF AGRICULTURE[7].

(4) Data Distribution

According to our data, the Amazon fulfillment centers are opened at different time (pic 1) in different places (pic 2).

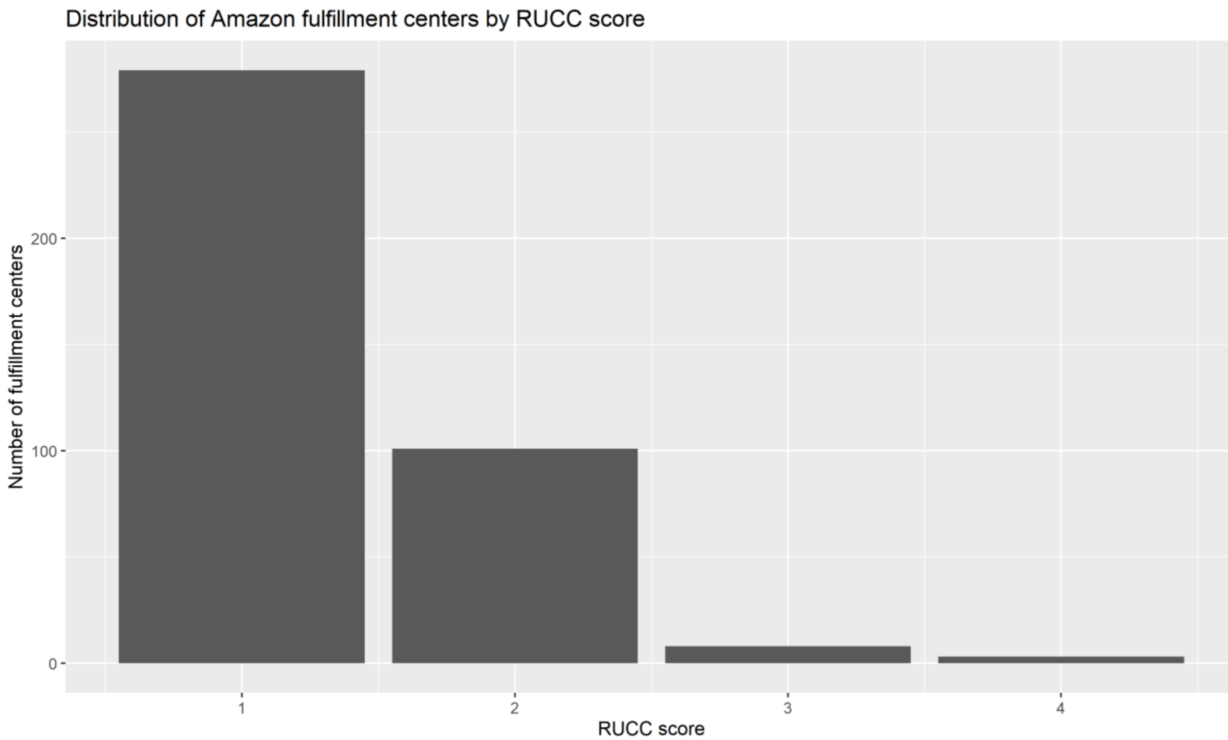


Pic 1 Number of Amazon Fulfillment Centers Opened by Year



Pic 2 Number of Amazon Fulfillment Centers Opened by State

Amazon fulfillment centers are in the areas where the RUCC score equals 1 - 4 (pic 3).



Pic 3 Distribution of Amazon fulfillment centers by RUCC score

B. Statistical Method

To estimate the effect of Amazon's fulfillment centers on PM2.5 levels in surrounding areas, we considered several econometric methods. The difference-in-differences (DiD) method is a commonly used approach to estimate the impact of a treatment on an outcome. However, this approach is not appropriate for our study due to the violation of the parallel trend assumption, which assumes that the trend in PM2.5 levels would have been the same between the treated group and the control group.

Therefore, we turned to the synthetic control method (SCM), which involves creating a weighted average of control areas that closely match the treated area. However, this method alone is not suitable for our study, as it is designed for a single treated unit and may not provide a good fit for our data, which involves multiple treated units.

Our solution to this problem is to incorporate a staggered adoption design in the SCM, which is called Synthetic Controls with Staggered Adoption[8]. This is a method that has been developed to address the challenge of multiple treated units that are opened at different times. This method involves creating a synthetic control group that closely matches the treated group in terms of pre-treatment outcomes and then estimating the effect of the treatment by comparing the post-treatment outcomes of the treated and synthetic control groups.

We used R package (*augsynth*) to implement the Synthetic Controls with Staggered Adoption method and estimate the effect of Amazon's fulfillment centers on PM2.5 levels in surrounding areas.

C. Parameters Setting

We included the Rural-Urban Commuting Area Codes (RUCC) score as an auxiliary covariate to ensure that the control group is similar to the treated group in terms of their rural-urban status. The treated group consisted of counties that had an Amazon Fulfillment center, while the control group consisted of counties that had never had one, matched to the treated group based on their RUCC score.

We analyzed the data for the years 2000-2018, collapsing treated units with the same treatment time into time cohorts. The level of partial pooling nu was set to 0.1, and the penalty parameter for the synthesis method lambda was set to 0.000135. We considered the impact of the treatment for 3 years after it was introduced.

IV. Results

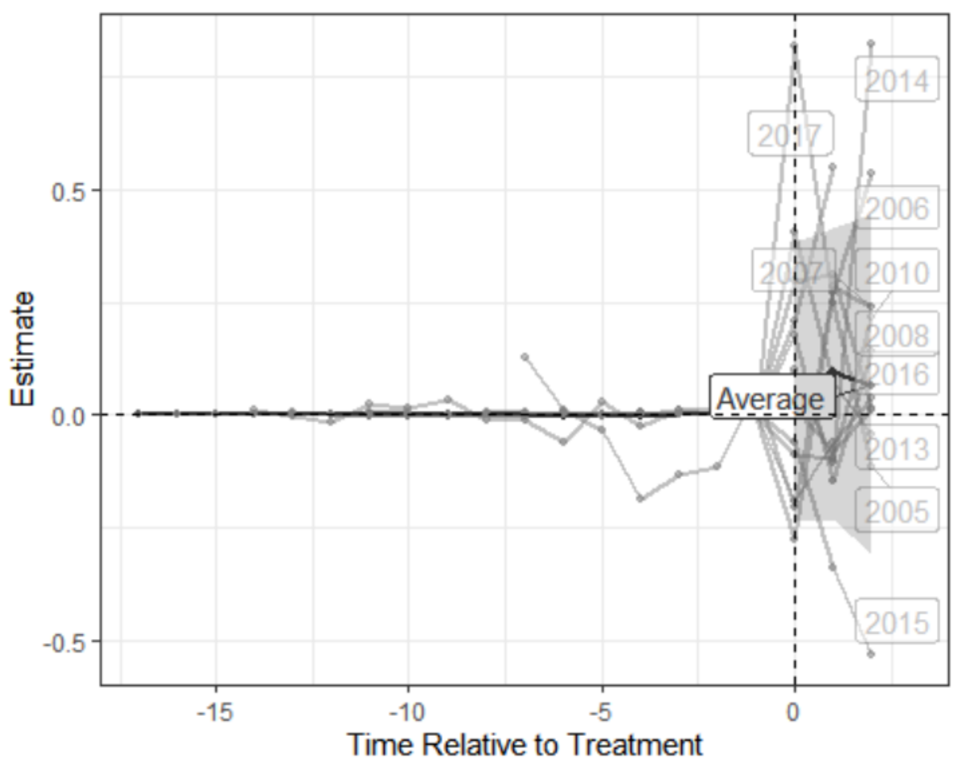
The results of the study show that the Average ATT Estimate is 0.098 with a standard error of 0.156. This suggests that the presence of Amazon fulfillment centers has a positive effect on the PM2.5 levels in surrounding areas.

The table below shows the estimates for the effect of treatment on PM2.5 levels at different time periods since treatment. The estimates indicate that the effect of treatment is relatively constant over time, with an average estimate of 0.064, 0.096, and 0.065 for time periods 0, 1, and 2 respectively. The standard errors for these estimates are relatively large, indicating some uncertainty in the results. However, the lower and upper bounds of the estimates suggest that the presence of Amazon fulfillment centers has a positive effect on PM2.5 levels, as they are all above zero.

Time Since Treatment	Level	Estimate	Std.Error	Lower bound	Upper bound
0	Average	0.06368450	0.1531511	0.2354696	0.3809860
1	Average	0.09622663	0.1690647	0.2341437	0.4165696
2	Average	0.06545656	0.1824701	0.3077763	0.4465734

Table 1 The ATT across the 3 post treatment periods

The plot (pic 4) below is generated based on the result shows that the effect of the treatment varies across the years, with most of the post-treatment years showing a positive effect. However, it's worth noting that the pre-treatment is balanced, but the post-treatment shows a large scale, suggesting that the effect may be influenced by other factors that were not accounted for in our analysis. Overall, our findings provide evidence that the Amazon fulfillment centers contribute to the increase in PM2.5 levels in surrounding areas.



Pic 4 The pre-treatment balance and the estimated treatment effects

V. Conclusions

Based on our analysis using the Synthetic Controls with Staggered Adoption method, we found that the opening of Amazon Fulfillment centers has a positive effect on PM2.5 levels in surrounding areas. Specifically, the Average ATT Estimate is 0.098 with a standard error of 0.156.

Our results indicate that the effect of Amazon Fulfillment centers on PM2.5 levels varies across the years, but the effect is generally positive in most of the years. The post-treatment period shows a large-scale increase in PM2.5 levels, which suggests that the presence of Amazon Fulfillment centers may be contributing to the increase in pollution.

It is worth noting that our study has some limitations. First, our analysis is based on observational data, and there may be unobserved factors that are driving the observed effects. Second, our study only focuses on PM2.5 levels, and we do not examine other pollutants or health outcomes. Future research could investigate the impact of Amazon Fulfillment centers on other pollutants and health outcomes.

Despite these limitations, our study provides important insights into the impact of Amazon Fulfillment centers on air pollution in surrounding areas. Policymakers and regulators should consider the potential environmental impact of new industrial developments, such as Amazon Fulfillment centers, on surrounding communities. It is important to ensure that the economic benefits of these developments do not come at the expense of public health and environmental quality.

VI. References

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