The emerging spectrum of flexible work locations: implications for travel demand and carbon emissions

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1. Introduction

Since the beginning of the COVID-19 pandemic, much has been made about the dramatic rise in working from home and the broader implications for society going forward. However, the simple term “working from home” belies the fact that people have been spending their remote work hours in a wide range of places: coffee shops, libraries, co-working spaces, friend’s living rooms. In this study, we demonstrate that the binary home-or-office-as-work-locations paradigm fails to capture the true dynamics of remote work, and can lead to overestimation of the impacts of remote work on two key indicators: demand for travel and travel-related carbon emissions. Furthermore, we show how mobile device data can be used to estimate commuting patterns for trips to non-home, non-work locations at a disaggregate level to facilitate long-term transportation planning.

There has been considerable research into the sudden increase in remote work adoption that resulted from the COVID-19 pandemic. In a working paper titled "Why working from home will stick", Barrero et al. show that remote work represented more than half of all worked hours in the United States during the height of the pandemic (see Figure 1). Furthermore, the authors find that remote work is expected to represent more than a quarter of all worked hours after the pandemic subsides, a five-fold increase from 2018.

Many recent studies have used survey instruments to estimate the impact of remote work on travel demand and congestion, as commuting trips are a significant portion of overall travel. In most cases however, the studies consider just two possible working locations, home and a fixed workplace, and use the term “work from home” in their surveys and analysis rather than the broader terms “remote work” or “flexible work”. As a result, any aggregate estimates of post-pandemic travel demand are likely to ignore trips made to alternative remote work locations, or “third places”. Understanding the use of third places is critical not only for travel behavior, but also for broad economic indicators such as employee satisfaction, firm productivity and the commercial real estate demand.

To study the current and future use of third places, the authors have included several questions in recent waves of the Survey of Workplace Attitude and Arrangements (SWAA), a
monthly survey of 5,000 working-age U.S. residents. We find that, after scaling the results to the demographics of the country, 11.8% of total worked hours in November 2021 happened at a third place (see Figure 2). This share represents 27.4% of all remote work hours. Furthermore, this trend is expected to continue after the pandemic subsides, albeit to a slightly lesser degree (Figure 3).

Figure 2: Distribution of worked hours in November 2021 by location type

Reported working hours at third places is relatively evenly split between the three categories included in the survey: public spaces (e.g. coffee shop or library), co-working spaces and the home of a friend or family member. Preferences for third places are not evenly distributed across the population, however. For example, the use of third places is more
prevalent in urban areas than suburban areas, as shown in Figure 4. Similarly, the use of third places varies considerably by income group as shown in Figure 5. It is clear from the survey data that third places represent a significant proportion of remote work, with complex preferences that differ between demographic and employment groups. Understanding these dynamics and their effect on travel behavior is an important step in preparing for the future of work.

In this paper, a model is developed to predict the use of third places based on employment and demographic information for the first time in literature. Then, the predicted distributions are synthesized with a pre-COVID travel survey to estimate a new set of origin-
destination commuting flows that include work trips to third places. Finally, the aggregate effect of these new origin-destination flows on total commuting distance and commuting-related carbon emissions are determined. To the author’s knowledge, this is the first study to consider the effect of third places on post-pandemic travel demand, and the first to develop a comprehensive method for predicting the disaggregate travel demand patterns resulting from the dramatic rise in third place remote work.

2. Data

There are three primary sources of data used in this analysis. The first is the SWAA which is administered by a consortium of academic institutions, including MIT [13]. The SWAA is the source of information for future remote work location preferences and includes demographic and employment data for each respondent. The second is the My Daily Travel Survey conducted by the Chicago Metropolitan Agency for Planning (CMAP) between 2018 and 2019 [14]. The CMAP survey includes detailed travel and personal information for over 12,000 households in the Chicago area and is available to the public. This is the source of information for existing (pre-COVID) commuting patterns which are then modified based on the mode and location changes predicted by the SWAA to produce an estimate of post-COVID commuting patterns. Origin and destination locations for each trip are available at the census tract level.

The final source of information is collected from SafeGraph, a data company that aggregates anonymized location data from numerous applications in order to provide insights about physical places. SafeGraph provides the locations of Points of Interest (POIs) and
relative visitation frequencies for retail businesses \cite{15}. SafeGraph information used to determine the distribution of locations for trips by remote workers to third places such as coffee shops and co-working spaces. Home locations for visitors are available at the census block group level.

Note that the CMAP survey is the only data source that is specific to the Chicago area (the SWAA and SafeGraph are both national in scope). Many state departments of transportation and Metropolitan Planning Organizations conduct similar surveys, so these results are largely generalizable to other U.S. metropolitan areas subject to data availability. The nationwide National Household Travel Survey could also be used to conduct a similar case study for the entire country, although doing so at the census tract or census block group level could present computational challenges. Chicago was chosen to illustrate the methods presented in this study as it represents a very large urban area with high demographic and economic diversity.

3. Methodology

This study uses a four step procedure to evaluate the impact of third places on the demand for urban mobility at a disaggreate level.

1. A model is developed to predict the distribution of flexible work location choice and mode shift for an individual based on employment and demographic characteristics.
2. Trips to third places are distributed among the available locations using revealed preference data.
3. The aggregate impact on commuting demand by mode is determined by removing pre-pandemic commuting trips when an individual is predicted to work at home, and replacing those commuting trips with the synthetic trips from Step 2 when an individual is predicted to work at a third place.
4. The impact on carbon emissions is computed from the overall change in travel distance by mode.

Each of the steps are explained in detail in the subsections that follow.

3.1. Location choice prediction

To estimate how commuting patterns and carbon emissions could change as a result of working from third places, first we must predict the distribution of location choices for flexible work. As discussed earlier, opportunities for remote work and preferences for third places are highly heterogeneous. For that reason, a disaggreate approach is applied wherein work location choices are predicted for each individual using employment and demographic information. A model is developed to predict, given a commuter with a specified set of demographic and employment variables, the fraction of pre-COVID commuting trips that fall into the following categories: A) eliminated due to working at home, B) have a modified destination due to working at a third place, and C) unchanged due to working at the employer’s work site. The trips within category B) are further distributed among the different types of third place: public space, friend’s home and co-working space.
Table 1: Input variables for work location choice model

| Variable                        | Variable Type |
|---------------------------------|---------------|
| Occupation Category (NAICS)     | Categorical   |
| Industry Category (NAICS)       | Categorical   |
| Household Income Category       | Categorical   |
| Sex                             | Categorical   |
| Age                             | Continuous    |
| Race                            | Categorical   |
| Education                       | Categorical   |
| Home ZIP Population Density     | Continuous    |

The scaled SWAA responses from November and December 2021 are used as training data for the prediction model. The full list of SWAA employment and demographic variables used in the model are presented in Table 1.

Several different econometric and machine learning model designs are under consideration, with accuracy and interpretability as the primary evaluation criteria. Furthermore, the design of a mode shift model is also underway based on the mode shift information available from the SWAA.

3.2. Third place locations

Creating new trips to third locations for future commuting patterns requires strong assumptions, but actual data was used wherever possible. There are three categories of third places in the SWAA questionnaire: public spaces, co-working spaces and the home of a friend or family member. As the specific locations were not included in the survey, it is not possible to compute the distribution of travel distances for each of these location types directly. An alternative means of estimating trip distances is therefore needed.

SafeGraph data uses mobile phone records to estimate the home locations of visitors to an extensive list of retail establishments. Establishment type is also included, so the distribution of visits from a given home location (at the census block group spatial resolution) to different establishment types can be determined. This method is used to create a distribution of public space and co-working space visit probabilities and the associated travel distances for every home census tract in the Chicago Metropolitan Area. The expected value of public space and co-working space trip distance for each home census tract can then be estimated.

SafeGraph data does not contain information about visits to residential locations, so an alternative method is needed to estimate trip distances to the homes of friends and family members. Rather than SafeGraph data, the CMAP survey was used as it contains information related to the purpose of each trip. Trips with the purpose of “socializing with friends” and “socializing with relatives” were used a proxy for visits to the homes of friends and family. While socializing can take place in non-home locations, the inclusion of other trip purposes such as “dining out”, “shopping”, “recreation” and “special event” is assumed to reduce the number of non-home-based social events in the chosen trip categories. Aggregating the CMAP survey social trip distances for each home location census tract therefore provides a reasonable estimate of the distribution of travel distances for trips to friend’s and family members’ homes.
3.3. Travel demand impacts

Once the predicted change in commuting frequency and location distribution at the individual level is determined, the aggregate effects on travel demand can be calculated. The 2018-2019 observed commuting distances are used as a baseline against which the predicted distances are compared. To demonstrate why the consideration of third places for remote work is critical, a “Home Only (HO)” scenario is generated based on the assumption that all remote work takes place at the home. Then a more realistic “Spectrum of Work Locations (SWL)” scenario is generated where some remote work takes place at third places. The overall change in aggregate travel distance and travel distance by mode will be reported for both the HO and SWL scenarios. Furthermore, the overall change in trips by origin and destination will be visualized by census tract for each scenario to identify spatial trends in third place commuting patterns.

3.4. Carbon emissions

There are two factors that contribute to the change in commute-related carbon emissions as a result of increased flexible work. The first and most critical is the anticipated reduction in commuting distance that results from working at home and third places rather than a fixed employer-specific workplace. The second is the change that arises from shifting from one commuting mode to another, as travel modes have significantly different emissions profiles. Using the difference in travel distance by mode from the previous section and multiplying by the average carbon emissions per unit distance by travel mode for the Chicago area, we can find the total change in carbon emissions for both the HO and SWL scenarios.

4. Expected Results

The expected results of this analysis are that the inclusion of third places for remote work will produce a meaningfully different set of commuting patterns when compared to the binary “home or office” scenario. Working from third places is expected to represent approximately 10% of total work hours and working from home is expected to represent approximately 30% total work hours after the pandemic subsides. Then, if third place trips are half as long as traditional commutes, total commuting distance will be reduced by 35%, rather than 40% as would be anticipated if all remote work took place from home. In other words, there would be 8.3% more travel than expected in the binary scenario. At the disaggregate level, it is anticipated that most third place trips will take place in largely residential areas, reflecting a shift from the long suburb-to-downtown commute towards a more convenient home-to-nearby commute.

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