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# HOW WORKING FROM HOME AND MIGRATION CAN AFFECT INCOME? EVIDENCE FROM THE UNITED STATES

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# HOW WORKING FROM HOME AND MIGRATION CAN AFFECT INCOME? EVIDENCE FROM THE UNITED STATES

Trabalho de conclusão de curso apresentado ao Instituto de Economia da Universidade Federal do Rio de Janeiro, como requisito para a obtenção do título de Bacharel em Ciências Econômicas.

Rio de Janeiro, 06/03/2023.

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## RESUMO

A pandemia COVID-19 mudou drasticamente a forma como trabalhamos. Nos Estados Unidos, por exemplo, cerca de 20 a 30% de todas as horas pagas agora são realizadas de forma remota. O aumento do trabalho remoto (WFH) está associado a um novo padrão de migração, com as pessoas deixando os centros urbanos para as áreas da periferia. A monografia explora a relação entre esses fluxos de migração, exposição ao trabalho remoto e renda média dos lares em um determinado código postal. Os resultados mostram uma correlação fraca e positiva entre o fluxo líquido de migração e a renda e uma relação negativa entre a exposição ao trabalho remoto e a renda. A pesquisa apresenta as implicações das novas tendências do trabalho remoto nos padrões de renda e fornece evidências para uma literatura mais ampla e ainda incipiente sobre o tema.



**Palavras-chave:** trabalho remoto; migração; renda

## ABSTRACT

The COVID-19 pandemic has dramatically changed the way we work. In the United States, for example, around 20-30% of all paid hours now being done remotely. The rise of work from home (WFH) has led to a new migration pattern, with people leaving urban centers for suburban areas. This thesis explores the relationship between these migration flows, WFH exposure, and median household income in a given zip code. The results show a weakly positive correlation between net migration flow and income, and a negative relationship between WFH exposure and income. This research sheds light on the implications of the WFH trend for income patterns and provides evidence for a broader incipient literature on the topic.



**Keywords:** working from home; migration; income

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## INTRODUCTION

The work from home (WFH) model has significantly risen in response to the social distance measures against COVID-19 across the world - particularly in the USA. In the current literature, several authors argue that there is a lasting shift in WFH adoption in the labor market, especially among high-income and well-educated workers. Some of them conducted surveys between 2020 and 2021 [BICK et al. (2020), DALTON; GROEN (2022) and BARRERO et al. (2021)] to measure how eager employers and employees were to work temporarily or permanently with the model and how they see WFH for the future. The results suggest that WFH-Only (remote work 5 days in a week) and WFH-Hybrid (remote work at least once per week) have become significantly more popular and even vital among certain sectors of the economy.

Beyond this uptake in remote work, new implications for the geography within and between cities emerge. Althoff et al. (2022), and Delventhal and Parkhomenko (2021) build spatial models and analyze migration patterns related to the new WFH model. The mechanism is similar in both authors; since the remote work shock in the labor market, workers may choose to not commute to their work onsite at all (WFH-Only) or at least once a week (WFH-Hybrid). That removes the urge to live nearby their work's site and, therefore, opens a variety of possibilities of new housing patterns. The models suggest that, in order to be closer to places with more amenities, people move further away from the center towards the periphery.

All of that, according to the authors, contributes to a new scenario in the labor market. Assuming remote work had a permanent shift, the implications that this new popularized model may have could be impactful; new migration patterns, changes in housing market, higher workers' bargain power, new distribution of space within a city, new work relations, change in preferences, etc. Considering that migration movement by telecommuters happens among the high-income and well-educated workers (ALTHOFF et al., 2022), they bring their earnings to these new areas, potentially improving their economy.

These new migration flows among telecommuters raise important questions: do they have a meaningful share of total migration flows? If so, is their influence over the economy significant? Is this influence different amid intra-county and inter-county migration? This thesis investigates the relationship between migration associated with remote work and its potential economic influence in the places of destiny of these teleworkers.

The thesis presents a regression analysis on the median household income (taken from the American Community Survey) over the working from home exposure (built with Dingel

and Neiman (2020) classification system and job distribution from the US Census Bureau) and the net population flow (taken from the United States Postal Service) in a zip code level, among other controls. The thesis followsthe Ramani and Bloom (2021) methodology that calculates the arc-percentage change of income pre and post 2020. The ultimate goal of the model is to test the thesis hypothesis that working from home and migration can affect the income in a given location.

The results suggest a non-robust positive relationship between in-migration and income and a negative relationship between pre-COVID WFH exposure and income. If supplemented by other papers, the results can support the thesis that zip codes with a high number of workers who could telework out migrate more - therefore lowering the zip's income - and go to other locations, where the zips are awarded with a growth in income by those movers. However, this explanation must be carefully taken into account, since some results do not hold with robustness tests.

Therefore, the thesis is structured as follows: a literature review over the recent publication on remote work, and its relationships with migration and economic activity; a section detailing the data and methods used in the regression analysis; a presentation of the results, possible interpretations and a robustness check on them and finally its conclusion.

# 1. THEORETICAL FRAMEWORK

With the popularization of remote work across the United States, researchers [RAMANI and BLOOM (2021), BICK et al. (2021), ALTHOFF et al. (2022)] have been studying the implications of such a phenomenon. One of these is how people migrate considering no work-onsite restraint and how that kind of migration can actually change economic activity in specific locations, measured by county GDP, consumer spending and tax revenue. This chapter presents the literature related to these three aspects - remote work, migration and economic activity - relating the mechanisms among them.

## 1.1 THE CURRENT LITERATURE ON REMOTE WORK

In the literature related to the uptake in WFH levels - which is called by De Fraja et al. (2021) as Zoomshock - and its continuity, most authors provide data - primary or secondary sources of data - to demonstrate that after the start of the pandemic there was a major shift in remote work adoption. The exact number differs depending on the source, but the time series tendency is clear among them. The papers also provide different kinds of explanation to such a phenomenon and why they mostly believe that WFH came to stay in the US labor market.

Aksoy et al. (2022) conducted a survey in 27 countries among full-time workers who finished primary school, in order to understand the effects of working from home (WFH) over each of these countries after the initial stages of the pandemic (the survey was taken 16 to 23 months after the pandemic onset). With the results, they draw strong evidence that there is a long and lasting uptake in WFH. Moreover, they designed an explanation of this phenomenon by pointing out that the pandemic induced re-organization and re-optimization of work arrangements, by creating an environment of social experimentation.

In 2019, when WFH was not common, on days they worked, 82% of employed people did all or some of their work at the workplace and 24% did it at home, compared to 2021, when the numbers were 68% and 38%, respectively. This reveals that not only firms were forced to adopt the model indiscriminately, in order to solve the restrictions imposed by social distancing measures, but also that the new introduced model is still being used by the workforce. This argument is supported by a 39% improvement in social acceptance of WFH in the US. The authors ground this assumption in the survey by a 39% increase in WFH social acceptance, and by an increase from 1.6 days WFH to planning in the future working up to an average of 2.1 days, in the US.

In that sense, when asked about their productivity gains compared to their expectations before COVID-19, over 87% of respondents think they are about the same or more productive, therefore indicating that a new work arrangement took place in workers' preferences. According to the authors, that could only be possible due to the pandemic massively forcing WFH in all kinds of occupations, leading to a learn-by-doing experiment.

> The simultaneity of large-scale experimentation is important in this regard. A law firm, for example, could have experimented with WFH before the pandemic. What it could not have done was experiment with WFH when the courts and other firms - including clients, rival law firms, consultants, and suppliers - also worked remotely. Had the COVID-19 pandemic not occurred, our evidence suggests that the big shift to WFH would have taken place much more slowly over many years (AKSOY et al.; 2022, page 17).

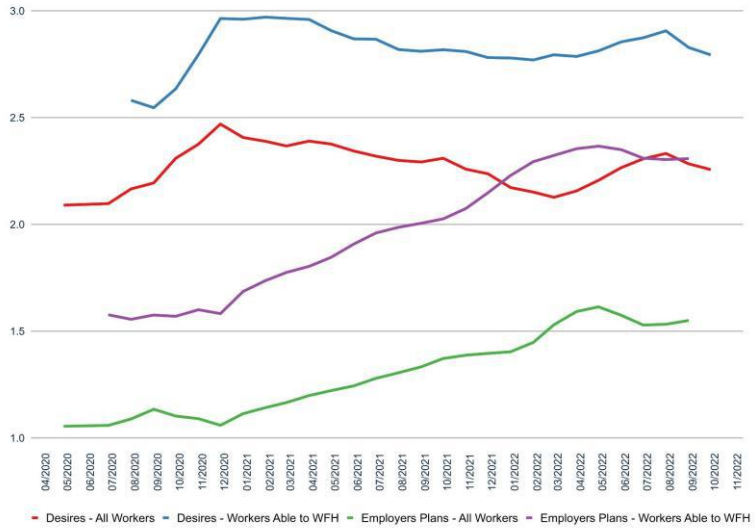
Barrero et al. (2021) designed the Survey of Working Arrangements and Attitudes (SWAA) to build cross-section data to exploit workers' and employers' perceptions about WFH. The survey has been fielded once a month since May 2020, and it is still being released every 5th day of the month. The authors argue that the COVID-19 pandemic drove a massive experiment in WFH across all the United States, which resulted in an uptake in WFH levels in the long-term, jumping from 4,8% of full paid working days at home before the pandemic to a peak of 61,5% in May 2020. Since then, the WFH levels have been dropping to stabilize at 30%.

**Figure 1 – WFH as % of full paid working days**


Source: prepared by the author based on Barrero et al. (2021).

The workers' desires and employers' plans of WFH also corroborates the thesis of a lasting-long-term shift in WFH in the US. Since the start of the survey, employers have been more eager to adopt WFH in firms. From an employee's perspective, WFH desired levels have been high since early 2021, as Figure 2 shows. The gap between worker desires (below 50%) and employer plans (about 20%) is where the actual WFH level should be, as they are now (30%).

**Figure 2 – WFH days**




Source: prepared by the author based on Barrero et al. (2021).

The authors developed a framework that explains these structural changes. First, the pandemic's experiment on WFH, result of social distance measures adopted by the government, extinguished social cost of experimentation for individuals and firms, by compulsorily making economic agents WFH, that otherwise wouldn't. In that sense, the average worker spends $561 in home equipment to better fit their needs to WFH. Also, US patent applications among WFH technologies doubled during 2020, which raise efficiency and quality of remote work, even enabling some industries that are less likely to WFH to be a part of this new work model.

That experimentation and new investment allowed agents to update their priors on WFH, reviewing their productivity on remote work upwards, comparing their view before the pandemic. That leads to a more acceptance over remote work, as suggested by Figure 2. The reduced commuting time is highly valued by qualified workers, since their opportunity cost per unit of time is greater than average, as discussed by other papers.

Bick et al. (2021) developed the Real-Time Population Survey (RPS) to track changes in the labor market due to the pandemic. The survey was designed to differentiate the adoption of WFH model among demographic groups, like age, gender, income, education, residence etc. and its impacts. Notably, they found that commuting time has largely fallen since early 2020 and recovered after the first COVID-19 wave. The authors also argue that the bulk in WFH was caused by WFH-Only workers, who work entirely remotely. They estimate that at the end of 2020, 20.4% of all employed still worked entirely from home. However, the paper's most important contribution is described by them:

> "[…] we develop a stylized model of WFH employment that leads to a clear distinction between two main channels through which a pandemic can cause large numbers of commuters to start WFH. The first is an intuitive WFH substitution channel. Because of the increased health risks of working away from home, workers substitute on-site work for working at home within working arrangements that already included the option to WFH before the pandemic. A key aspect of this channel is that, for those that switched to WFH in the pandemic, by revealed preference home-based work is less efficient than on-site work in a normal health situation; if it were not, those workers would have already worked from home before the pandemic. The second channel is a WFH adoption channel. In this channel, the increased health risks of on-site work in the pandemic force changes to work arrangements through the adoption of a WFH option and/or of new technologies that enable WFH. A key aspect of this channel is that many of those that switched to WFH in the pandemic could in principle already have worked more productively from home before the start of the pandemic, for instance because of advances in information and communication technology. However, because of adoption lags, social norms or general inertia, employers did not provide the option to WFH until the pandemic." (BICK et al.; 2021, pages 2-3)

The adoption channel, according to the authors, explains the differences in WFH transition in certain labor markets. They find that after the pandemic, the ability to WFH is strongly correlated to the WFH level in different occupations. That correlation, however, that effect is much smaller before the pandemic and there were not that many differences across occupations. With that said, to explain why high WFH-ability sectors were not already working remotely before the pandemic they must have experienced larger costs on working on-site, which means a greater job loss in those sectors. Nonetheless, those were the occupations with lower job loss rates. In that sense, the adoption channel enabled them to break inertia and adopt WFH.

Brynjolfsson et al. (2020) were one of the first to develop a survey to track COVID-19 and labor market. In their findings, around May 2020, 35,2% of people who were commuting transitioned to the WFH model. They also have found that in the early stages of the pandemic, the share of workers WFH could be predicted by the incidence of COVID-19, corroborating the thesis of the pandemic driving a massive social-experimentation on WFH. They also found differences in WFH according to workers' occupation and industry.

Dalton and Groen (2022) analyze the 2021 Business Response Survey to "present estimates to telework patterns during the […] pandemic". In line with other authors, they found that 12.6% of jobs involved teleworking on a full-time basis and 21.8% on a part-time basis. They also had information of WFH adoption discriminated by all kinds of characteristics, such as flexibility, whether had change in payment, change in square footage space on-site, independent, freelancer, voluntary or other, and industry.

In terms of occupations and incidence of remote work, the results follow Dingel and Neiman (2020) classification model of teleworkability. Information, Financial activities and Professional and business service are all sectors with high propensity to WFH and are among the three sectors with largest remote work percent of jobs.

Dey et al. (2021) use data from the Current Population Survey, which added questions about remote work after the pandemic, to measure WFH incidence in the United States and the impact of COVID-19 in the labor market as a general. From May to June 2020, roughly one third of the workforce teleworked due to the COVID-19 pandemic. That number dropped in the following months, reaching 22.3% by the last quarter, which follows Barrero et al. (2021)'s SWAA. The authors also advocate in support of the permanently shift in WFH:

> "It seems likely that some of the increase in teleworking will be permanent as workers and employers gain experience with teleworking arrangements and with the information technology that helps facilitate teleworking." (DEY et al.; 2021)

The authors also present a revised classification of teleworkability according to the North American Industry Classification System introduced by Dingel and Neiman (2020), in order to improve some aspects of the categorization.

## 1.2 THE CURRENT LITERATURE ON REMOTE WORK AND MIGRATION

Since the COVID-19 outbreak, several papers tried to model the relationship between remote work and the spatial distribution of workers [DELVENTHAL et al. (2021), ALTHOFF

et al. (2022), DELVENTHAL and PARKHOMENKO (2020), CORREA (2022), RAMANI and BLOOM (2021) and LIU and SU (2021), De FRAJA et al. (2021), HASLAG and WEAGLEY (2021)]. That seems to be an important implication of remote work for these authors because the Zoomshock solved the historical restraint in the housing choice that workers prefer to live near their work's site. In that sense, less commuting time leads to more welfare and, as stated by Aksoy et al. (2022), to a reallocation of resources, including in the real estate market.

Delventhal et al. (2021, page 1) study the shape of Los Angeles using "a quantitative model featuring local agglomeration externalities and endogenous traffic congestion". They contribute to the remote work literature as they find changes in wages and real estate prices, commuting patterns, and an increase in welfare caused by a more widespread telecommuting. Delventhal and Parkhomenko (2020, 2022) expand the analysis to a national level, discriminating by education and industry. The authors build a model which robustly predicts migration patterns in the US between 2020 and 2021.

Using cell phone data from SafeGraph, Althoff et al. (2022) draw a positive correlation between likelihood of remote work and out-migration. They found that areas where zip code had high shares of business service workers presented more outflows of workers. They adopted Eckert et al. (2020) definition of these workers' industries of skilled scalable services (SSS) consisting of North American Industry Classification System (NAICS) industries 51, 52, 54 or 55[1]. Then, the authors used Dingel and Neiman (2022) classification of potential of remote work (Table 1, left panel) to divide industries by their likelihood of telecommuting. By that definition, SSS workers are the group with the largest remote work (Table 1, right panel), therefore showing that WFH is correlated to out-migration.

[1] The industries are 51 - Information; 52 - Finance and Insurance; 54 - Professional, Scientific, and Technical Service; and 55 - Management of Companies and Enterprises.

**Table 1 – WFH exposure by Industry**

| | Unweighted | Weighted by wage | | Annual Income (USD) | Remote Work Potential (%) |
|---|---|---|---|---|---|
| Educational Services | 0.83 | 0.71 | Skilled Scalable Services (SSS) | 84,000 | 79.6 |
| Professional, Scientific, and Technical Services | 0.80 | 0.86 | | | |
| Management of Companies and Enterprises | 0.79 | 0.86 | Resources + Construction | 54,900 | 19.7 |
| Finance and Insurance | 0.76 | 0.85 | Manufacturing | 60,900 | 32.1 |
| Information | 0.72 | 0.80 | Trade + Transport | 40,300 | 22.5 |
| Wholesale Trade | 0.52 | 0.67 | Education + Medical | 48,500 | 50.6 |
| Real Estate and Rental and Leasing | 0.42 | 0.54 | Arts + Hospitality | 22,600 | 14.4 |
| Federal, State. and Local Government | 0.41 | 0.47 | Other Services | 39,400 | 33.9 |
| Utilities | 0.37 | 0.41 | | | |
| Other Services (except Public Administration) | 0.31 | 0.43 | | | |
| Administrative and Support and Waste Management and Remediation Services | 0.31 | 0.43 | | | |
| Arts. Entertainment, and Recreation | 0.30 | 0.36 | | | |
| Mining, Quarrying, and Oil and Gas Extraction | 0.25 | 0.37 | | | |
| Health Care and Social Assistance | 0.25 | 0.24 | | | |
| Manufacturing | 0.22 | 0.36 | | | |
| Transportation and Warehousing | 0.19 | 0.25 | | | |
| Construction | 0.19 | 0.22 | | | |
| Retail Trade | 0.14 | 0.22 | | | |
| Agriculture Forestry, Fishing and Hunting | 0.08 | 0.13 | | | |
| Accommodation and Food Services | 0.04 | 0.07 | | | |

Source: prepared by the author based on Dingel and Neiman (2020) and Althoff et al. (2022)

Furthermore, the authors also found that big high-density cities - which concentrated SSS workers and had the greatest share of workforce WFH - were the targets of the migration outflow of high-income service workers. That has manifested a decline in consumer spending in consumer service industries, which require lower-skilled workers. Althoff et al. (2022) supports this idea by showing that the decline in weekly hours of non-SSS in high density areas is greater than low density areas. This dynamic can be explained by the authors:

> With improvements in technology and high-speed internet, many business service jobs can now be done remotely, so that big cities' specialization in business services has translated into a specialization in remote work jobs. [...] the recent COVID-19 pandemic has accelerated the transition [...].
>
> Such a transition is likely to affect business and consumer service workers differently due to the differences in markets served. As high-skill service workers transition to remote work, they become more mobile, and may leave big city centers with high rents for regions with lower costs of living or more favorable amenities. When they depart big cities, they take their demand for consumer services with them. As a result, the transition to remote work is likely to hurt less-mobile consumer service workers in big cities the most (ALTHOFF et al., 2022, page 1).

It is also important to note that no matter the density, SSS workers are almost equally affected by the change in hours worked, across all the time series, meaning that remote work muffles regional shocks to the labor market. It is important to highlight that these papers use data from the ACS and CPS to get economic, social, housing, demographic and migration data

of the US, along with private companies' data to get information about migration flows and real estate prices.

Ramani and Bloom (2021) study the new migration pattern related to WFH after the pandemic. They discovered what they call a "donut effect", where people and businesses move further away from the center - which in their paper has a proper definition and construction which they call central business districts (CBD) -, populating more peripheral areas, imitating the shape of a donut. Their second discovery is that the migration across metropolitan areas is much smaller than within-metropolitan areas.

To reach these results, they built an analytical spatial equilibrium model, consisting of two metro areas, one bigger and the other smaller, each one with a center and suburb. Using real estate price data from Zillow, WFH exposure built from Dingel and Neiman (2020) classification method and LODES data, and migration data from USPS, the authors estimated the relationship between the pandemic and WFH exposure with the new migration's patterns. Quantitatively, monthly population outflows from CBDs increased almost 2% related to pre-pandemic levels, in the 12 largest metro-areas in the US.

But for this work's purpose, the paper's findings about between-metro migration raise intriguing questions. First, they show that the outflows of people and businesses from the center across-cities are proportionally weaker than within-metro reallocation. Second, they show a positive relationship between population density and real estate price, when comparing different cities, suggesting that "real estate markets expect denser metros to perform well in the longer-term" (RAMANI AND BLOOM, 2021). In that sense, the WFH-Hybrid model could play an important role: people move further away from CBDs, searching the benefits of living in suburbs, but cannot live too far away from their workplace, since they are required to work onsite once or more per week.

By another perspective, Correa (2022) examines how the ability to WFH (work from home) contributes to the out-migration decision from large cities in Sweden. In contrast with the previous studies, he finds that people who are more likely to WFH are less likely to migrate. The author uses an European-based index (based on SOSTERO et al., 2020) to build his model and emphasizes that whether his results generalize to other countries remains to further discussion, but it is in line with Ramani and Bloom (2021). The authors found a significant movement of workers from the centers to the suburbs, but not across cities. The results are explained by the hybrid work, in which workers have to commute one or more days per week, bounding them to the city where they work, and consequently downplaying the role of remote work in the new geography of work.

Liu and Su (2021, page 1), in line with Ramani and Bloom (2021), use real estate data with Dingel and Neiman (2020) classification system to find out that there is a "shift in housing demand from central cities and dense neighborhoods to the suburbs [...]". They conjecture about the reasons for such a movement. First, denser neighborhoods are close to center jobs, which concentrate high-skilled workers, who are more likely to WFH and, therefore, would have the largest drop in housing demand. Second, these areas tend to have consumption amenities, like bars and restaurants, which were closed in the peak of the pandemic, and would not be a premium to those who live closer to them, at that moment. Third, these areas have higher costs, and as the need to live in these locations diminishes, people would not value paying those costs.

Haslag and Weagley (2021, page 1) find that "households are moving more for non-work-related reasons, and that they are moving to lower rent, lower tax, and less populous areas after the onset of the pandemic". Though, it is important to note that this change in behavior is different across demographic and income groups; lower-income households still tend to move for job-related reasons and are less likely to move for non-work reasons, in contrast with high-income households - which here we can define as the SSS workers - that are the group with the greatest change in behavior. The authors also highlight the role that WFH plays in the move decision:

> "[...] our results support many of the theoretical predictions and corroborate survey evidence that remote work is having a significant impact on the migration of workers and is likely to continue to play a role in migration decisions in the future as well". (HASLAG and WEAGLEY; 2021, pages 7-8)

The paper's focus is on interstate migration flows, which is not representative for all mover's population, and may not capture broader migration trends. However, the authors used the CPS migration data in an interstate level to address this issue, by comparing changes in behavior in their original database (UniGroup) and in CPS pre and post-pandemic. Moreover, corroborating for the thesis that remote work is now established in the labor market, their results of migration as a consequence of COVID-19 stand through the end of 2021, meaning that the temporary causes such as the pandemic itself and social distancing measures play a lesser role than permanent causes, like the Zoomshock.

Furthermore, given that the SSS workers have a greater share of the income and they are more likely to WFH, their relocation into smaller suburbs and towns is - following Moretti's (2010) argument - likely to impact the local economies. That supports the general concern

among researchers that the Zoomshock has economic impacts which need to be better approached in future research.

Brueckner et al. (2021) explore how the WFH option affects the spatial hedonic equilibrium. They call attention to two possible kinds of migration due to the introduction of remote work. Workers can either move from high-productive, expensive areas to low-productive and cheaper neighborhoods or they can move to find high-amenity places, and they can do both options without losing their high-productive jobs. The authors then develop a spatial equilibrium model to highlight the new possibilities. The major difference between the two is that the housing prices are inverse one to the other: while the prices tend to rise in the high-amenity places, they tend to fall in the high-productive ones, and vice versa. Though there are some features present in both effects:

> "Underlying both outcomes are two key features of the new hedonic equilibrium: wage equalization across cities, which must occur when people can work anywhere; and a disconnect between a city's population and employment levels, which are no longer equal." (BRUECKNER et al.; 2021, page 2)

Within a city, the migration outcomes may differ from the intercity moves. For workers in the hybrid WFH model, they still have to commute to their offices, therefore maintaining some physical connection to them. Even so, they value of proximity to the center business district (CBD) is lowered, hence implying "a reduction in the city's housing-price gradient, with prices under WFH falling more slowly than before moving away from the CBD (the job-access premium thus falls)". (BRUECKNER et al., 2021, p. 2)

## 1.3 THE CURRENT LITERATURE ON REMOTE WORK AND ECONOMIC ACTIVITY

Since the migration patterns due to remote work are concentrated in the Donut Effect (RAMANI and BLOOM, 2021), there is a major concern about changes in economic activity around these areas. Ramani and Bloom (2021, page 13) states that since SSS workers are more likely to WFH, the reallocation of those workers is "likely to make the drop in consumption spending on services especially large". In particular, that is important to understand because it may lead to significant drop in tax revenue of the county government.

Althoff et al. (2022) observe that this drop in consumption affects the non-SSS workers, because their income depends on SSS workers spending, in general terms. Therefore,

the non-SSS workers within large metro areas experienced the largest falls in revenue, compared to those living in other cities.

De Fraja et al. (2021) address the issue of how the increased WFH levels impact local economies and employment, following the argument that the non-SSS workers - particularly those who provide locally-consumed services (LS) such as retail and hospitality - are more likely to be negatively affected by the new migration flows caused by the Zoomshock. They use a survey made in the United Kingdom to find that the impacts of remote work depend on demographic characteristics, income and education - like other authors such as Ramani and Bloom (2021) and Althoff et al. (2022) - and that around 1.5% of total spending is estimated to relocate away from urban center to residential areas.

In other words, they estimate "approximately 77,000 jobs in retail and hospitality will either need to similarly relocate or be lost altogether" (De FRAJA et al., 2021, page 2). They follow their argument by highlighting that the demand for office-space may fall, as remote work becomes more prominent, even though the total extent of this impact depends on "how firms adapt their use of space given increased remote work" (De FRAJA et al., 2021, page 31). That leads to two possible outcomes; first, a need to re-purpose this extra space in city centers, possibly driving a new implication in the remote work geography, and second, reduced economic externalities that benefit LS workers.

## 2. DATA AND METHODS

To investigate how the remote workers who have moved after the pandemic onset have economically affected the region where they migrated to, I rely on Ramani and Bloom (2021) model analysis[2]. The authors verify if WFH exposure, density and distance from the center of the city in a given zip code affect the rent prices and net flows of migration. Their result shows that there is a significant link between the variables, using a regression model.

To increment their findings, I try to model the relationship between the median household income of a zip code after the pandemic and the net flow of migrants along with the regressors the authors already used, mentioned above.

### 2.1 DEPENDENT AND CONTROL VARIABLES

I use the **median household income** from the American Community Survey (ACS) as the economic variable of interest. It is one measure of the average income of households in a given geographic area - which in this case is at the zip code level. The data is collected annually by the U.S. Census Bureau, in the largest household survey in the United States, collecting information from over 3 million households each year.

The data used covers from 2018 up to 2021 - the most recent release -, taken from the 5-year estimates of the ACS. The total data address the issue of income earnings in almost all of the US zip codes, serving as a proxy for economic activity across the years of a given location.

Also, to calculate the percentage difference of median income in all the US zip codes, I use the arc-percentage methodology. This method, introduced by Davis, Haltiwanger and Schuh (1996), is a method used to calculate the percentage difference of a variable over time or across different geographic regions. This methodology is particularly useful when the changes in the variable of interest are non-linear, such as in the case of the change in income compared to traditional linear methods.

To track the **migration flows**, I use the dataset provided by the United States Postal Service (USPS), the National Change of Address (NCOA). The dataset contains monthly data

[2] The original idea was to build a DiD model, but the data is organized in a way that the treatment (immigrants who migrate because of WFH) cannot be identified. Therefore, I used the approach taken by Ramani and Bloom (2021)

of net migration flow of families, households, businesses and total migration in a zip code level. I use the same treatment made by Ramani and Bloom (2021), described by them:

> [...] we multiply the number of household change-of-address requests by 1.7, the mean household size of moving families in the US and add the number of individual change-of-address requests. The data also bottom-codes zip code-month flow counts to 0 if the value is less than or equal to 10 due to privacy concerns. We impute such values with the midpoint, 5 [...] (RAMANI and BLOOM; 2021, pages. 6-7)

To measure the **WFH incidence** in a given zip code, I use the Ramani and Bloom (2021) index of share of employment and share of income that can be done from remote work (**WFH exposure**). To build the measure, they used the job industry distribution for residents across US zip codes from the LEHD Origin-Destination Employment Statistics (LODES) at the US Census Bureau. Then, they merged the data with the Dingel and Neiman classification of remote work probability to find the WFH exposure of income and employment. This dataset is built using 2019 LODES data, to obtain the exposure before the Zoomshock took place with the COVID-19 pandemic.

The mapping of zip codes to their corresponding **metro area's Central Business District (CBD)** is based on data from Holian (2019). The study evaluates various sources and techniques for determining CBD coordinates and determines that the 1982 Census of Retail Trade's official coordinates accurately reflect the city's center of concentration. Since the 1982 Census only defines CBD coordinates for 268 metro areas, the CBD for the remaining areas is defined using the city's City Hall. In cases where both the 1982 Census and City Hall exist, the City Hall coordinates usually align with the 1982 Census CBD coordinates. The CBD area is defined as all zip codes whose centroids are within 2 kilometers of the CBD coordinates. I used the Ramani and Bloom (2021) measure of distance of each zip code to the nearest CDB.

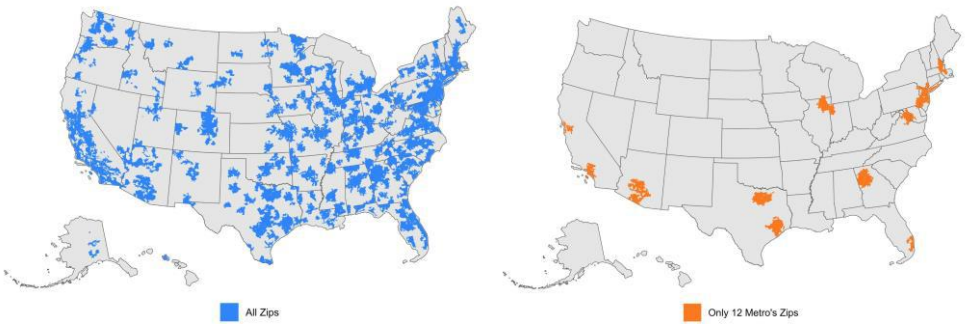
Other zip code characteristics are used as control variables. **The population density** is calculated using the 2015-2019 American Community Survey (ACS) pooled estimates from IPUMS (Manson et al, 2020). **Land area** is from the Census Bureau's zip Code Tabulation Area files. Zip codes with less than 100 people or less than 0.1 sq miles of area are filtered out in analysis. Zip code coordinates are obtained from the Census Bureau's Gazetteer files and used to determine **distance from the CBD**. **Business establishment data** is from the 2018 zip Code Business Patterns dataset.

The final dataset used as input for the model was built using the data sources described in the previous section. I borrowed Ramani and Bloom (2021) treatment for the data, adding

the median household income from the American Community Survey as the dependent variable. That gives a dataset with six determinant independent variables used as covariates; WFH exposure, net flow of migration, population density, distance of the zip code from the nearest Center Business District and which CBD is that, and the arc-percentage change of income before the pandemic (the change after the pandemic is used as the dependent variable.

Given that, there are two rounds of models to be considered; one with zip codes from all over the United States (All-zips), and other with 12 selected Metropolitan areas[3] (12-Metro). From all the 33,120 different zip codes in the United States, I used roughly 44.1% of them (14,631) in the All-zips models and 10.9% of them (3,622) in the 12-Metro models. Figure 3 shows which ones are used.

**Figure 3 – Maps with the zip-codes considered in the analysis**




Source: prepared by the author based on US Census.

When weighting by total area, the zips considered in the All-zips models represent 26.4% of total area in the US, while the 12-Metro models represent only 2.7%. However, the zips in the All-zips models represent 82.6% of the total population in the US in 2019. The 12-Metro zips have 28.8% of the total population. As done by Ramani and Bloom (2021), I have filtered all zip codes with less than 100 people or less than 0.1 square mile of area. Tables 2.1 and 2.2 show tables with descriptive statistics of the most relevant variables used in the analysis, for both All-zips and 12-Metro models.

**Tables 2.1 and 2.2 – Descriptive Statistics of the variables used in All-zips model (up) and 12-Metro model (down)**

| All-zips model | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Variable** | **N** | **Mean** | **Std. Dev.** | **Min.** | **Pctl.25** | **Pctl.50** | **Pctl.75** | **Max.** |
| post_inc_pct_change | 14,626 | 5.57 | 7.66 | -78.15 | 2.58 | 5.45 | 8.62 | 85.25 |

[3] The Metropolitan areas are: Boston, MA; Chicago, IL; Dallas, TX; Houston, TX; Los Angeles, CA; Miami, FL; New York, NY; Philadelphia, PA, Phoenix, AZ; San Francisco, CA; Washington, DC.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| pre_inc_pct_change | 14,587 | 7.43 | 10.66 | -85.04 | 2.31 | 7.20 | 12.47 | 102.35 |
| wfh_emp | 14,631 | 0.35 | 0.05 | 0.16 | 0.31 | 0.34 | 0.37 | 0.60 |
| net_pop_20 | 14,608 | -0.09 | 3.85 | -172.32 | -1.26 | -0.05 | 1.03 | 77.35 |
| density_2019 | 14,631 | 2,542 | 6,947 | 0.15 | 105.01 | 593.61 | 2,744 | 149,036 |
| dist_to_cbd | 14,631 | 31,661 | 24,724 | 60,545 | 13,721 | 25,885 | 43,453 | 447,262 |
| 2019_population | 14,631 | 18,522 | 17,499 | 56 | 4,376 | 12,998 | 28,301 | 128,294 |
| **12-Metro model** | | | | | | | | |
| **Variable** | **N** | **Mean** | **Std. Dev.** | **Min.** | **Pctl.25** | **Pctl.50** | **Pctl.75** | **Max.** |
| post_inc_pct_change | 3,562 | 5.69 | 6.23 | -53.42 | 3.10 | 5.47 | 8.41 | 58.39 |
| pre_inc_pct_change | 3,553 | 8.24 | 9.18 | -54.79 | 3.55 | 7.84 | 12.64 | 85.76 |
| wfh_emp | 3,564 | 0.38 | 0.05 | 0.19 | 0.34 | 0.37 | 0.41 | 0.60 |
| net_pop_20 | 3,562 | -0.26 | 4.12 | -52.34 | -1.51 | -0.27 | 1.03 | 77.35 |
| density_2019 | 3,564 | 6,367 | 12,248 | 2.29 | 869.21 | 2,922 | 6,423 | 148,862 |
| dist_to_cbd | 3,564 | 39,622 | 28,422 | 226.53 | 17,762 | 33,157 | 55,570 | 174,203 |
| 2019_population | 3,564 | 26,489 | 20,342 | 157 | 10,069 | 23,076 | 37.874 | 128,294 |

Source: prepared by the author based on ACS, USPS NCOA, LODES and Dingel and Neiman (2020)

## 2.2 MODEL SPECIFICATION

The goal of the model is to address changes in median income as a result of the WFH exposure and the migration flow across the US zip codes. To achieve this, I use a multiple linear regression, which models the response variable's - in this case, the change in income - relationship to its explanatory variables. Using the ordinary least squares method, one can calculate the independent variable' predictors, leading to an equation (WOOLDRIGE, 2012)

The model used is specified as follows:

$$\%\Delta income_{i,t} = \alpha + \beta_1 \%\Delta income_{i,t-1} + \beta_2 pop_i + \beta_3 ln\ density_i + \beta_4 ln\ dist\_CBD_i + \beta_5 ln\ WFH\_exp_i + \boldsymbol{\psi} + \epsilon_i$$

Where $i$ stands for the zip code index, $\psi$ is a vector of dummy variables, each one them indicating one Metro Area (for the two rounds of models), $\%\Delta income_t$ is the arc-percentage change of the median household income from 2020 to 2021, and $\%\Delta income_{t-1}$ is the arc-percentage change from 2018 to 2019. The model also addresses the control variables used by Ramani and Bloom (2021); the density in 2019, the distance from the Center Business District to the zip, the WFH employment exposure in 2019 and the net population flow in 2020 as a percent of total population, all in zip code level. Furthermore, as mentioned above, the models are weighted by total zips' population, meaning that a zip with more population has a greater impact over the zip with less population.

Even though the regression analysis has some interesting characteristics, such as the prediction of the conditional mean of the response variable, given certain values in the

explanatory variables, or the coefficient of determination, which is the proportion of the variation of the dependent variable explained by the model, for this thesis, these are not important. What I am interested in is the values of the coefficients in the equation, more particularly, their signal and if they are significant.

The significance of a predictor variable says whether its value is just a chance of fortune or it really is significant, or put in other words, whether the null hypothesis of it is being rejected. Usually, the significance levels considered are 5%, 1% and 0.01%, each one of them meaning one, two or three stars in the results table. For this thesis analysis, a significant predictor means that it is a variable important in the model context to explain the variation of the response variable. However, that should not be interpreted as a causal effect on a variable over another, since certain assumptions must be taken into account and more robust modeling techniques should be used.

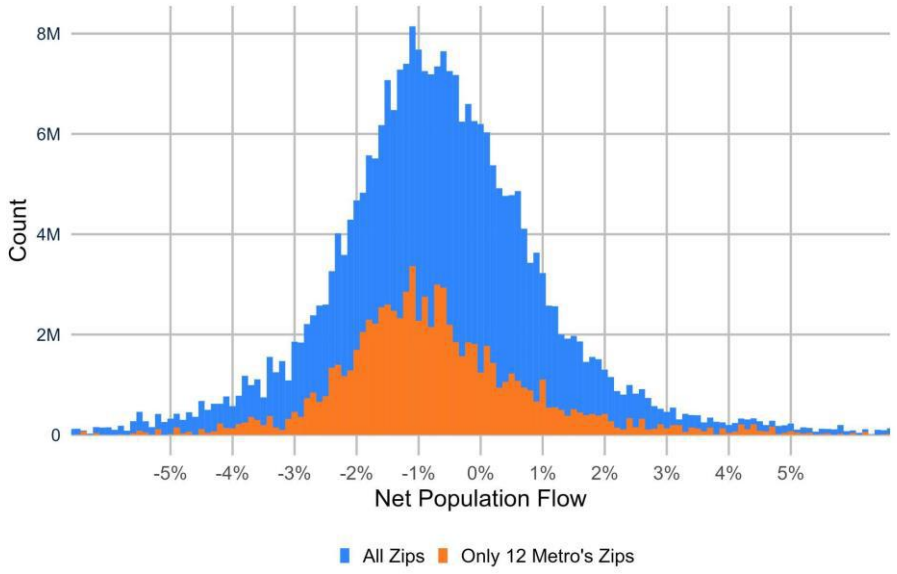
Therefore, the coefficients would give how the independent variables relate to the dependent variable; whether it is positive or negative. In the case of a numerical explanatory variable X, if X has a positive coefficient, on average, more of X results in more of Y (the response variable). If the coefficient is negative, more of X results in less of Y. The numerical variables in the model can be percentages or log-transformed variables, which differentiates the interpretation on how much of Y increases or decreases, but that is not important for the analysis, and thus is not considered. The categorical variable used is the dummy variables of the nearest CBD to the zip code. If a dummy variable is significant, then being near to that specific CBD can change the income arc-percentage change by its own.

## 3. RESULTS AND DISCUSSION

It is worth taking account of the distribution of variables used in the model, notably the pre and post COVID-19 arc-percentage income change, the net population flow and the WFH exposure. Since in the models the variables are weighted by the zips' total population, the distribution of the variables is also explored, weighting them by population.

The distribution of net population flow in 2020 shows its skewness towards emigration from the zip codes. That means that people are, on average, out-migrating more from both the All-zips and 12-Metro models zip codes than immigrating. Since the NCOA dataset has limited information about migration - about one quarter of the total zip codes is not contained in it - there is no full track of the flows. However, given that highly populated zips have between 0% and 2% population loss, it is possible to hypothesize people are moving away from the centers towards suburbs, as discussed in the literature review (Ramani and Bloom (2021) and Althoff et al. (2022) propose this explanation), but verifying that hypothesis goes beyond the scope of this thesis.

**Figure 4 - Distribution of net population flow, weighted by zips' population**




Source: prepared by the author based on USPS NCOA.

Figure 5 shows the distribution of WFH exposure index of employment, created by Ramani and Bloom (2021), weighted by population. The histogram suggests that the majority of the zips are located between 30% and 45% of WFH exposure, with the 12-Metro zips being

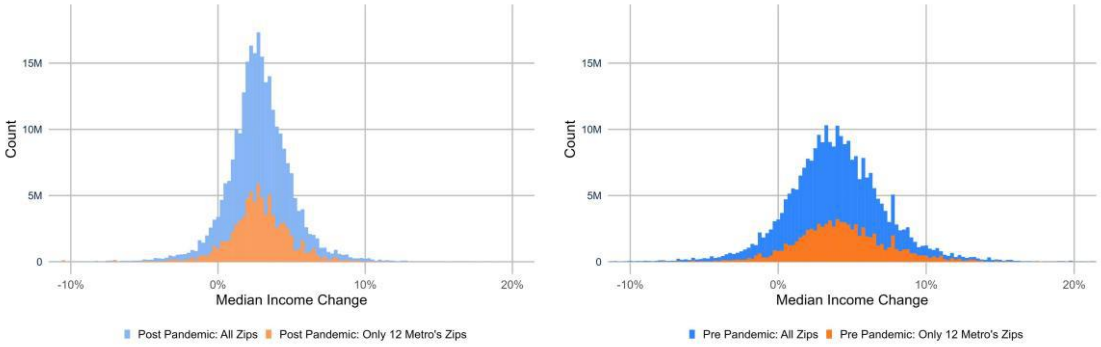
skewed towards more exposure, compared to the All-zips zips. As discussed by Barrero et al. (2021), by the end of 2022, roughly 30% of all paid hours in the US are worked in the remote work model, which is completely plausible with the index.

**Figure 5 - Distribution of WFH exposure, weighted by zips' population**


Source: prepared by the author based on Ramani and Bloom (2021).

Finally, Figures 6.1 and 6.2 show the distribution of the arc-percentage change in income before and after the pandemic (2019 to 2020 and 2020 to 2021, respectively). The post change is much more concentrated than the pre change, since the COVID-19 tackled the economy, and different locations had similar retake in the income change levels.

**Figures 6.1 and 6.2 - Distribution of pre and post pandemic median household arc-percentage income change, weighted by population**




Source: prepared by the author based on American Community Survey.

## 3.1 GENERAL RESULTS

Table 3 shows the results of the regression analysis for four different model specifications: in models (1) and (2) all zip codes with data are used as observations, but model (2) has dummy variables for nearest Metropolitan areas and model (1) does not. Models (3) and (4) have only zip Codes in the 12 largest Metropolitan areas in the US, and following models (1) and (2), model (4) has dummy variables for nearest Metropolitan areas and model (3) has not.

**Table 3 – Regression results**

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | post_inc_pct_change | | | |
| | (1) | (2) | (3) | (4) |
| pre_inc_pct_change | -0.039*** | -0.070*** | 0.002 | -0.025** |
| | (0.006) | (0.006) | (0.011) | (0.012) |
| net_pop_20 | 0.076*** | 0.057*** | 0.038 | 0.080* |
| | (0.018) | (0.020) | (0.044) | (0.045) |
| log(density2019) | 0.148*** | -0.200*** | -0.020 | -0.200** |
| | (0.029) | (0.047) | (0.079) | (0.093) |
| log(dist_to_cbd) | -0.029 | -0.454*** | -0.251** | -0.461*** |
| | (0.050) | (0.069) | (0.125) | (0.135) |
| log(wfh_emp) | -1.973*** | -3.171*** | -3.187*** | -3.955*** |
| | (0.322) | (0.398) | (0.611) | (0.640) |
| Constant | 3.092*** | 7.547*** | 5.224*** | 8.391*** |
| | (0.750) | (1.754) | (1.745) | (1.921) |
| Observations | 14,587 | 14,587 | 3,553 | 3,553 |
| $R^2$ | 0.007 | 0.070 | 0.008 | 0.041 |
| *Note:* | | | | *p**p***p<0.01 |

Source: prepared by the author based on ACS, USPS NCOA, LODES and Dingel and Neiman (2020).

In summary, the regression models suggest that there is a negative relationship between the growth of income before the pandemic and after it. Hence zip codes which presented increasing earnings in income now have less income increase. Also, the WFH exposure before the pandemic is negatively correlated with income growth. The two results combined can suggest that zips where there was a lot of workers who could potentially telecommute and had high income – Althoff et al. (2022) draw the positive correlation between high income and probability of telecommuting – before the pandemic simply migrate to other areas, relocating with their income and, finally, diminishing income growth after the Zoomshock. It is worth noting that the effect of WFH exposure holds for all four models, meaning that it is indeed a significant feature.

Furthermore, the net population flow in 2020 is positively correlated with income, meaning that if a zip had a positive net migration, then the income would increase. In this

scenario, migration as a whole would increase earnings in income, but supplementing this result with the explanation of the last two coefficients above, and assuming it is right, it could also imply that the migration motivated by remote work-related reasons has a positive relation with the income growth.

The distance between the zip and the Center Business District is negatively correlated with the dependent variable for the models with the dummy variables for the Metro area, meaning that a high distance from the center zip has a lower income growth. In that sense, centers had higher earnings than periphery, even though there is a Donut Effect in which people tend to move away from the center into suburbs (RAMANI and BLOOM, 2021). The result suggests that the fact of being in a center leads to higher paying, no matter the effects described above.

Finally, the zip density in 2019 is the feature with two possible correlations with income: negative and positive. Considering that the coefficient in model (3) is not significant, density is positively correlated when not combined with Metro areas dummies (or not correlated at all, as in model 3), and negatively with the Metro dummy variables. That leads to a possible interpretation of the density variation being explained by the dummies, changing its signal.

In conclusion, the results suggest the hypothesis of remote work and migration affecting income is verified, and alongside the explanation given, that people with potential to WFH moved and brought their income with them, increasing the median income of the region they migrated to, there is a well-established interpretation of the model results. However, this thesis aims only to provide evidence for such a phenomenon, and still needs more modeling exercises to attribute a causal effect of remote work migration over income. The following section discusses how the results hold given the assumptions needed to this interpretation are violated.

## 3.2 DIAGNOSTIC TESTS

To verify if the results are reliable, one can make diagnostics tests and check if the overall interpretation of the model still stands even after them. This is especially important when there are potential violations of the underlying assumptions of the model, such as linearity, normality, and homoscedasticity. Therefore, a diagnostic test helps to mitigate the impact of these violations by using a more robust estimation method.

In this case, I use the same check made by Ramani and Bloom (2021), which consists in using the robust standard errors to assure the coefficients are still significant. The use of

robust standard errors can also help to protect against the effects of outliers, which can have a substantial impact on ordinary standard errors.

Additionally, a diagnostic test provides a check on the validity of the model, which can help to ensure that the results are not solely driven by outliers or a particular subset of the data. By conducting a diagnostic test, the analyst can be more confident in the validity of the results and the conclusions that can be drawn from the analysis.

Robust standard errors are calculated using a method called the sandwich estimator, which takes into account the covariance structure of the data. This results in a more accurate representation of the variability of the estimators, which in turn leads to more reliable hypothesis tests and confidence intervals, however the interpretation of the model is still the same. Table 4 shows the results using the robust standard errors.

**Table 4 – Regression results with robust standard errors**

| | *Dependent variable:* | | | |
|---|---|---|---|---|
| | post_inc_pct_change | | | |
| | (1) | (2) | (3) | (4) |
| pre_inc_pct_change | -0.039*** | -0.070*** | 0.002 | -0.025 |
| | (0.011) | (0.011) | (0.025) | (0.025) |
| net_pop_20 | 0.076** | 0.057 | 0.038 | 0.080 |
| | (0.034) | (0.035) | (0.064) | (0.075) |
| log(density2019) | 0.148*** | -0.200*** | -0.020 | -0.200 |
| | (0.044) | (0.076) | (0.124) | (0.147) |
| log(dist_to_cbd) | -0.029 | -0.454*** | -0.251 | -0.461** |
| | (0.087) | (0.127) | (0.200) | (0.229) |
| log(wfh_emp) | -1.973*** | -3.171*** | -3.187*** | -3.955*** |
| | (0.536) | (0.680) | (0.866) | (0.947) |
| Constant | 3.092** | 7.547*** | 5.224* | 8.391*** |
| | (1.261) | (2.684) | (2.746) | (3.216) |
| Observations | 14,587 | 14,587 | 3,553 | 3,553 |
| $R^2$ | 0.007 | 0.070 | 0.008 | 0.041 |
| *Note:* | | | | *p**p***p<0.01 |

Source: prepared by the author based on ACS, USPS NCOA, LODES and Dingel and Neiman (2020)

With the new standard errors, some of the coefficients lose significance, meaning that the model must be carefully interpreted as a good predictor of the median income. First, the WFH exposure still stands after the new estimation, concluding that it is indeed a variable with significant explanation over the income. Yet the other critical covariate to the interpretation of the model, net population flow, loses significance in models (2) and (4), remaining significant only in model (1). Therefore, migration has a positive effect on income over all zip codes, when not using dummy variables for the nearest CBD, while in the others the effect is actually null.

The pre pandemic arc-percentage change of median household income and the density of the zip code remain significant only for the All-zips models, while the 12-Metro it does not hold. Finally, the distance from the nearest CBD of each zip code is significant only in the models that have a metro dummy. With the new results, the conclusion made is that the analysis made by inspiration of Ramani and Bloom (2021) of the 12 largest metropolitan areas is less robust than the analysis made by all over the country.

As several of the coefficients lose significance with the robustness standard errors, the overall interpretation loses its explanatory power. To address the issue, and determine whether migration motivated by remote work really had a direct influence over income – which is established by Ramani and Bloom (2021) and Althoff et al. (2022) – new exercises should be done in future research, increasing the pool of evidence in that matter.

## FINAL REMARKS

Working from home has come to stay in our everyday life. It is still too soon to measure its long-term influences in markets and society, but since 2020 it has gained more attention and more papers are added to the literature, providing new evidence of its effects. This thesis tries to contribute to the debate by showing evidence that remote work and the new migration flows associated with it can be related to income growth, thus altering the economy.

The literature has pointed out that there is in fact a new migration flow motivated by the possibility of working from home (RAMANI and BLOOM, 2021 and ALTHOFF et al., 2022) and it has conjectured about it. The conclusion is that when people who can WFH migrate, they leave with their income to the new place. On average, those who migrate because of WFH have higher income and do skilled scalable service jobs, and can migrate to areas with more amenities, without quitting their jobs. Considering that non-SSS workers do not WFH, on average, they still live near their work onsite, and lose revenue from the workers who migrated and do not consume there. However, the non-SSS workers who live on the destiny of the movers benefit from the shock on local spending.

This thesis adds more evidence to that explanation by the multiple linear regression model of arc-percentage change in income after the pandemic explained by WFH exposure before the pandemic and net population flow after it. The mechanism is that places more exposed to WFH before the pandemic had a loss of income after the shock because the SSS workers have moved. And places with high inflow of people had higher income gains. This dynamic is addressed in both between and within cities, since the model is in zip code level.

The thesis focuses in a relatively not explored subject of WFH and migration in the current literature, that is how the local economies respond to the newcomers who migrate because of remote work. Also, the thesis provides a consistent, relevant and updated literature review that summarizes the main data sources and methods used in research of WFH.

However, the debate is far from ending. The evidence provided by the model results is not causal, nor is it robust enough to have final word on the subject. New data can be added to enrich the model and explainability, along with the update to the current data, which only accounts for four years. New robustness tests can be made to ensure that the results are reliable and different strategies in the modeling can be done to input causal inferences on the results interpretation. That ought to be done in future researches.

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