A New Norm? Exploring the Shift to Working From Home in the Post-Pandemic Labor Market

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Abstract

This study evaluates the impact of the increase in remote work on labor outcomes using a search and matching model that incorporates changes in remote work disutility, commuting costs, and remote workers' productivity. The results show that the increase in commuting costs since the COVID-19 pandemic can have a negative impact on the employment rate in both urban and rural areas. Reducing remote work disutility can lead to a win-win situation by improving the well-being of the unemployed and reducing the well-being gap between rural and urban areas, while also increasing overall wealth in both economies. However, it is not enough, by it own, to fully absorb the negative impact of increased commuting costs. The study suggests that a public policy funding the increase in commuting costs through a tax proportional to workers' wages is a valuable option up to an increase of 42%, on average.

Keywords: Working From Home, Commuting Costs, Urban and Rural areas, Unemployment.

JEL Classifications: E24, J21, J24, J61, J64

1 Introduction

According to a study by Barrero et al. (2020), it is estimated that 20% of full workdays will be supplied from home in the Post-COVID economy. This increase in remote work is attributed to a number of factors, including better-than-expected remote working experiences, investments in physical and human capital that facilitate remote work, reduced stigma associated with remote work, concerns about crowds and contagion risks, and a pandemic-driven surge in technological innovations that support remote work.

In this paper, we build a search and matching model. We propose an original extension of the DMP model, which introduces *(i)* the choice to work fully on-site, remotely or in hybrid arrangement and *(ii)* the optimal choice of the time spent working from home in the hybrid set up. The model also accounts for regional heterogeneity between urban and rural areas. This model is calibrated to reproduce some important labour market facts in the Pre-COVID economy. The estimation of the model shows that the disutility of doing remote work is 38.5% higher for rural workers than urban ones which reflects the fact that urban areas tend to have more infrastructure and resources that support remote work, such as high-speed internet, coworking spaces, and other amenities that makes it easier for workers to work from home or other remote locations.

Using this calibrated model, we explain which parameters has been impacted since the Pre-COVID economy . First, the fuel prices rose from an average of 2.91$ in 2018 to 4.04$ in 2022 according to the US Department of Energy making workers less willing to commute and work on site. In fact, relationship between commuting and labour market outcomes has been studied several time before. Some studies highlights that longer commuting time can reduce job matching efficiency and increase unemployment duration, as workers may face geographical constraints reducing the pool of potential job offers available to workers[1].

Second, the COVID-19 pandemic has dramatically changed the perception of working from home. Before the pandemic, working from home was often seen as a convenience for some type of workers. However, with the outbreak of the pandemic and the enforced social distancing measures, the shift to remote work was mandatory to ensure business continuity. This pushed many employees who had never worked from home before to adapt to a remote work environment. This has shown that remote work can be a viable

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[1] In the exhaustive list you can find Berg and Gorter (1996), Nijkamp et al. (2000),Ommeren et al. (2000), Ommeren and Fosgerau (2009), Ruppert et al. (2009), Rouwendal (2004), Guglielminetti et al. (2020). Also see Zenou (2009) for an over view on commuting in urban economics.

option for many types of jobs, and many workers have reported enjoying the flexibility and lack of commute associated with working from home. Hence, the negative perception on remote work has shifted.

Finally, remote workers productivity is in the center of debates. On one hand some debate that there was an increase from productivity that may come from : *(i)* Reduced commute time and costs, which can lead to less stress and more time for work or other activities. *(ii)* Greater flexibility and autonomy, which can help workers manage their time more effectively and reduce distractions. *(iii)* More comfortable working environments, which can improve focus and concentration. *(iv)* Improved work-life balance, which can lead to greater job satisfaction and motivation. In fact, Natalia Emanuel and Harrington (2021) conducted a study on 500 online retailer of a call-center and showed that productivity, measured as hourly calls rose by 7.5%. However, despite these positive productivity effects, remote workers were 12 percentage points less likely to be promoted which can be one of the factors of the disutility of working from home. Bloom et al. (2015) conducted a randomized controlled trial with a Chinese travel agency and found that remote workers productivity had a 13% increase compared to the control group. Choudhury et al. (2021) studies the effect of a transition from a work-from-home to a work-from-anywhere program on productivity at the United States Patent and Trademark Office using a natural experiment and showed that it had a 4.4% increase in output. Etheridge et al. (2020) examine self-reported productivity of home workers during lockdown is UK and shows that for jobs that are suitable to be remotable report higher productivity on average.

On the other hand, others prone that productivity of remote workers has decreases. In fact, Gibbs et al. (2021) studied data on Asian IT services company and showed that although hours worked increased, average output declined with an estimated decrease of productivity of 8 to 19%. However this study focuses on shift from fully in-person to fully remote without a control group and can hence suffer from bias. Nevertheless, the lost in productivity may be explained by : *(i)* Difficulty separating work and personal life, which can lead to burnout or distractions. *(ii)* Lack of social interaction and support, which can lead to feelings of isolation and decreased motivation. *(iii)* Technical issues or limitations, such as slow internet speeds or incompatible software, which can hinder productivity. *(iv)* Difficulty collaborating with colleagues or accessing necessary resources, which can slow down work processes.

Hence, in this paper, we include the three main shifts that influences the workers decisions on whether to work from home or on site (increase in commuting costs, decrease in the disutility of working from home and the increase in workers productivity) and analyse their effect on some main labour market features as unemployment rate and wages. More, precisely, we show than the Post-COVID economy can suffer from the increase in commuting costs although the decrease in the disutility in remote work and the increase in productivity of remoters can partially offset this negative impact.

Furthermore, we show that if the disutility of remote work is sufficiently low, this negative effect can be fully absorbed. Specifically, we find that for a decrease of 40% or more, the negative effect of commuting costs is entirely absorbed, compared to the Pre-COVID case. However, we show that reducing the disutility of remote work, up to a reasonable point, does not eliminate the need for increasing remote workers' productivity to mitigate the negative shock of commuting costs. Hence, as it is not feasible to have 100% of remote work in the economy as most jobs are not entirely remotable, results highlight the fact that even if public policy focuses on subsidising working from home, it is crucial to acknowledge that further increases in commuting costs could still harm workers in both urban and rural areas.

Last but not least, we conduct an analysis on the well-being of the unemployed and economic wealth. It highlights the benefits of reducing remote work disutility. In fact, results depicts a win-win situation by improving the well-being of the unemployed and reducing the well-being gap between rural and urban areas while increasing in the same time the overall wealth in both economies.

Finally, in the light of the continuous increase in commuting costs, we study the effect of a public policy funding the increase in commuting costs through a tax that affects all workers equally and proportionally to their wages. Results show that this subsidy is a viable option up to an increase of 48% in commuting costs for rural areas, while for urban zones, it is only a feasible option up to an increase of 37%. The average for the economy is 42%. This public policy has no impact on both the well-being of unemployed workers and the wealth of the economy.

The remainder of this paper is organized as follows. Section 2 presents the model, and Section 3 discusses data and the model fit regarding the Pre-COVID data. Section 4 depicts the model's results of the shift in disutility in remote work. Section 5 presents the policy recommendations. Finally, Section 6 concludes.

2 The Model

We aim to analyze the effect of working from home on the labour market with Search and Matching frictions. The model features *(i)* the choice to work fully on-site, remotely or in hybrid arrangement, *(ii)* the optimal choice of the time spent working from home in the hybrid set up and *(iii)* heterogeneity between two regions: urban and rural areas.

2.1 Search

Spatial labour market and search process : The economy is divided in 2 heterogeneous spatial labour markets: urban and rural. In each spatial zone there is a representative firm. Firms in the different spatial zones produce the same good. However there is a heterogeneity in the productivity levels between the two areas.

Following Den Haan et al. (2000), the matching function for each sector is[2]:

$$M(x,y) = \frac{xy}{(x^{\mu} + y^{\mu})^{1/\mu}},$$

The number of contacts for works within the same zone as the firm[3]

$$M_{jj} = M(V_{jj}, U_j)$$

The number of contacts with workers from the other zone

$$M_{ji} = M(V_{ji}, \underbrace{U_i}_{\text{unemployed coming from zone } i \neq j})$$

Noting that $\theta_{ji} = \frac{V_{ji}}{U_i}$ and $\theta_{jj} = \frac{V_{jj}}{U_j}$, the job finding rate is given by

$$f_{jj} = \frac{M_{jj}}{U_j} = (1 + \theta_{jj}^{-\mu})^{-1/\mu}$$

and respectively,

$$f_{ji} = \frac{M_{ji}}{U_i} = (1 + \theta_{ji}^{-\mu})^{-1/\mu}$$

The probability of a vacancy to be filled is given by

$$q_{jj} = \frac{M_{jj}}{V_{jj}} == (1 + \theta_{jj}^{\mu})^{-1/\mu}$$

and finally

$$q_{ji} = \frac{M_{ji}}{V_{ji}} = (1 + \theta_{ji}^{\mu})^{-1/\mu}$$

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[2] This matching function imply that the job finding and vacancy filling rate lay between $[0; 1]$

[3] The first index (the second) is for the working (residing) area

Law of Motion of Employment : Workers can apply simultaneously to both labour markets. Once a worker and a firm match, the commuting time is revealed. The choice between working full time on-site, remote or hybrid is based on a joint decision between the firm and the worker through Nash Bargaining. Hence, the law of motion of employment in firm j is given by:

$$\begin{aligned}
N^{o}_{jj,t} &= (1-s_j)F(\tau^{R_1}_{jj,t})[N^{o}_{jj,t-1}+N^{h}_{jj,t-1}+N^{r}_{jj,t-1}+q(\theta_{jj,t-1})V_{jj,t-1}] \\
N^{h}_{jj,t} &= (1-s_j)\left(F(\tau^{R_2}_{jj,t}-F(\tau^{R_1}_{jj,t})\right)[N^{o}_{jj,t-1}+N^{h}_{jj,t-1}+N^{r}_{jj,t-1}+q(\theta_{jj,t-1})V_{jj,t-1}] \\
N^{r}_{jj,t} &= (1-s_j)\left(1-F(\tau^{R_2}_{jj,t})\right)[N^{o}_{jj,t-1}+N^{h}_{jj,t-1}+N^{r}_{jj,t-1}+q(\theta_{jj,t-1})V_{jj,t-1}] \\
N^{o}_{ji,t} &= (1-s_j)F(\tau^{R_1}_{ji,t})[N^{o}_{ji,t-1}+N^{h}_{ji,t-1}+N^{r}_{ji,t-1}+q(\theta_{ji,t-1})V_{ji,t-1}] \\
N^{h}_{ji,t} &= (1-s_j)\left(F(\tau^{R_2}_{ji,t})-F(\tau^{R_1}_{ji,t})\right)[N^{o}_{ji,t-1}+N^{h}_{ji,t-1}+N^{r}_{ji,t-1}+q(\theta_{ji,t-1})V_{ji,t-1}] \\
N^{r}_{ji,t} &= (1-s_j)\left(1-F(\tau^{R_2}_{ji,t})\right)[N^{o}_{ji,t-1}+N^{h}_{ji,t-1}+N^{r}_{ji,t-1}+q(\theta_{ji,t-1})V_{ji,t-1}]
\end{aligned}$$

2.2 Workers

As stated before, there are three type of workers: On site, remote and hybrid workers $e=\{o,r,h\}$ and two spatial zones: urban and rural $j=\{u,r\}$. Each worker can work either on site, remotely or in a hybrid setting in his own residential area or in the other one. Workers will weight there utility of working on-site or remotely through two parameters: *(i)* commuting costs and *(ii)* disutilisty of working remotely. In fact, if a worker chooses to work on-site he will pay a commuting cost $c_{j,\tau}\tau_{j,t}$. However if he choose to work remotely he endures a disutility noted ζ_j. Finally, if he chooses to work in hybrid mode (using λ as the share in remote work), the worker will pay $1-\lambda$ of commuting costs. However, we make the assumption that the share of doing remote working has a non-linear effect on the disutility of doing remote work. This is due to the fact that the disutility of remote work may increase over time, if remote workers experience social isolation, reduced work-life balance, and blurred boundaries between work and personal life[4]. Moreover, we assume that hybrid workers pay a flexibility costs $c_{h,j}$, due to the switch between different work environments. For example, workers may need to adjust their schedules to accommodate the days they work in the office, or they may need to be prepared to work from different devices or software depending on their location.

Hence, the values of working for a worker n residing in zone j are given by[5]:

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[4] See, Golden (2006)

[5] The value are symmetrical for worker residing in the other area. See in the Appendix 7.1 for the

$$W^o_{n,jj,t}(\tau) \quad = \quad w^o_{n,jj,t}(\tau) - c_{j,\tau}\tau_{n,j,t} + \beta \begin{bmatrix} (1-s_j)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{n,jj,t+1}(\tau)dF(\tau) \\ +s_jU_{n,j,t+1} \end{bmatrix} \tag{1}$$

$$W^h_{n,jj,t}(\tau) \quad = \quad \begin{array}{l} w^h_{n,jj,t}(\tau) - (1-\lambda_{n,j,t})c_{j,\tau}\tau_{n,j,t} - f(\lambda_{n,j,t})\zeta_j - c_{h,j} \\ +\beta \begin{bmatrix} (1-s_j)\int_0^{\tau^{R}_{j,t+1}} W^o_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R}_{j,t+1}}^{\tau^{max}} W^r_{n,jj,t+1}(\tau)dF(\tau) \\ +s_jU_{j,t+1} \end{bmatrix} \end{array} \tag{2}$$

$$W^r_{n,jj,t} \quad = \quad w^r_{n,jj,t} - \zeta_j + \beta \begin{bmatrix} (1-s_j)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{n,jj,t+1}(\tau)dF(\tau) \\ +s_jU_{n,j,t+1} \end{bmatrix} \tag{3}$$

$$U_{j,t} \quad = \quad b + \beta \begin{bmatrix} f_{jj,t}(1-s_j)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{jj,t+1}(\tau)dF(\tau) \\ +f_{jj,t}(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^r_{jj,t+1}(\tau)dF(\tau) \\ +f_{jj,t}(1-s_j)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^h_{jj,t+1}(\tau)dF(\tau) \\ +f_{ij,t}(1-f_{jj,t})(1-s_i)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{ij,t+1}(\tau)dF(\tau) \\ +f_{ij,t}(1-f_{jj,t})(1-s_i)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^r_{ij,t+1}(\tau)dF(\tau) \\ +f_{ij,t}(1-f_{jj,t})(1-s_i)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{ij,t+1}(\tau)dF(\tau) \\ +f_{jj}s_jU_{j,t+1} \\ +f_{ij}(1-f_{jj,t})s_iU_{j,t+1} \\ +(1-f_{ij,t})(1-f_{jj,t})U_{j,t+1} \end{bmatrix},$$

With $f(\lambda_{n,j,t}) = 1 - (1-\lambda_{n,j,t})\left(1 - log(1-\lambda_{n,j,t})\right)$ allowing to have $f(0) \to 0$, $f(1) \to 1$, $lim_{\tau\to 0}\lambda = 0$ and $lim_{\tau\to+\infty}\lambda = 1$. In fact, the optimal remote frequency in the hybrid

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values of worker residing in j and working in i

sitting is given by solving $\frac{\partial W^h_{n,jj,t}}{\partial \lambda_t} = 0$, leading to :

$$\lambda^*_{n,j,t} = 1 - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}}$$

Noting $e \in \{o, h, r\}$, hence we can rewrite our previous problem as :

$$W^e_{n,jj,t}(\tau) \quad = \quad \begin{array}{l} w^e_{n,jj,t}(\tau) - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}} c_{j,\tau}\tau_{n,j,t} - f(1 - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}})\zeta_j - I_{e=h}c_{h,j} \\ +\beta \begin{bmatrix} (1-s_j)\int_0^{\tau^R_{j,t+1}} W^o_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^R_{j,t+1}}^{\tau^{max}} W^r_{n,jj,t+1}(\tau)dF(\tau) \\ +s_j U_{j,t+1} \end{bmatrix} \end{array} \tag{4}$$

$$\begin{cases} W^e_{n,jj,t}(\tau) = W^o_{n,jj,t}(\tau) & \text{for} \quad \tau_{n,j,t} \leq \tau^{R_1}_{j,t} \\ W^e_{n,jj,t}(\tau) = W^h_{n,jj,t}(\tau) & \text{for} \quad \tau^{R_1}_{j,t} \leq \tau_{n,j,t} \leq \tau^{R_2}_{j,t} \\ W^e_{n,jj,t} = W^r_{n,jj,t} & \text{for} \quad \tau_{n,j,t} \geq \tau^{R_2}_{j,t} \end{cases}$$

2.3 Firm:

We make two assumptions on the productivity levels: (i) There is a difference in productivity levels between urban firms and the rural one and (ii) the workers have different qualifications in the two zones, making their productivity also different.

$$y_{uu} = y_{rr} \times (1 + \alpha_1) \times (1 + \alpha_2)$$

$$y_{ur} = y_{rr} \times (1 + \alpha_1)$$

$$y_{ru} = y_{rr} \times (1 + \alpha_2)$$

Noting $N_{j,t} = \sum_e \sum_I N^e_{ji,t}$, $\widetilde{w}^o_{jj,t} = \frac{\int_0^{\tau^{R_1}_{j,t}} w^o_{njj,t} dF(\tau)}{F(\tau^{R_1}_{j,t})}$ and $\widetilde{w}^h_{jj,t} = \frac{\int_{\tau^{R_1}_{j,t}}^{\tau^{R_2}_{j,t}} w^h_{njj,t} dF(\tau)}{F(\tau^{R_2}_{j,t}) - F(\tau^{R_1}_{j,t})}$, the firm's objective is to maximize its discounted profits:

$$
\begin{aligned}
\mathcal{V}_{j,t}(N_{j,t}) &= \max_{V_{jj,t},V_{ji,t},N^o_{jj,t},N^r_{jj,t},N^h_{jj,t},N^o_{ji,t},N^r_{ji,t},N^h_{ji,t}} D_{j,t} + \beta\mathcal{V}_{j,t+1}(N_{j,t+1})
\end{aligned}
$$

$$
\text{s.t} \quad \left\{ \begin{array}{rcl}
 & & y_{jj,t}(N^o_{jj,t} + N^r_{jj,t} + N^h_{jj,t}) + y_{ji,t}(N^o_{ji,t} + N^r_{ji,t} + N^h_{ji,t}) \\
D_{j,t} & = & -\widetilde{w}^o_{jj,t}N^o_{jj,t} - \widetilde{w}^r_{jj,t}N^r_{jj,t} - \widetilde{w}^h_{jj,t}N^h_{jj,t} - \widetilde{w}^o_{ji,t}N^o_{ji,t} - \widetilde{w}^r_{ji,t}N^r_{ji,t} - \widetilde{w}^h_{ji,t}N^h_{jj,t} \\
 & & -\kappa V_{jj,t} - \kappa V_{ji,t} \\
N^o_{jj,t} & = & (1-s_j)F(\tau^{R_1}_{jj,t})[N^o_{jj,t-1} + N^h_{jj,t-1} + N^r_{jj,t-1} + q(\theta_{jj,t-1})V_{jj,t-1}] \\
N^h_{jj,t} & = & (1-s_j)\left(F(\tau^{R_2}_{jj,t}) - F(\tau^{R_1}_{jj,t})\right)[N^o_{jj,t-1} + N^h_{jj,t-1} + N^r_{jj,t-1} + q(\theta_{jj,t-1})V_{jj,t-} \\
N^r_{jj,t} & = & (1-s_j)\left(1 - F(\tau^{R_2}_{jj,t})\right)[N^o_{jj,t-1} + N^h_{jj,t-1} + N^r_{jj,t-1} + q(\theta_{jj,t-1})V_{jj,t-1}] \\
N^o_{ji,t} & = & (1-s_j)F(\tau^{R_1}_{ji,t})[N^o_{ji,t-1} + N^h_{ji,t-1} + N^r_{ji,t-1} + q(\theta_{ji,t-1})V_{ji,t-1}] \\
N^h_{ji,t} & = & (1-s_j)\left(F(\tau^{R_2}_{ji,t}) - F(\tau^{R_1}_{ji,t})\right)[N^o_{ji,t-1} + N^h_{ji,t-1} + N^r_{ji,t-1} + q(\theta_{ji,t-1})V_{ji,t-} \\
N^r_{ji,t} & = & (1-s_j)\left(1 - F(\tau^{R_2}_{ji,t})\right)[N^o_{ji,t-1} + N^h_{ji,t-1} + N^r_{ji,t-1} + q(\theta_{ji,t-1})V_{ji,t-1}] \\
q(\theta_{jj,t})V_{jj,t} & \geq & 0 \qquad\qquad\qquad\qquad\qquad\qquad (\lambda^f_{jj,t}) \\
q(\theta_{ji,t})V_{ji,t} & \geq & 0 \qquad\qquad\qquad\qquad\qquad\qquad (\lambda^f_{ji,t})
\end{array} \right.
$$

The first-order conditions (FOCs) are

$$
\begin{aligned}
0 &= -\kappa + \beta\left[\frac{\partial\mathcal{V}_{j,t+1}}{\partial N^o_{jj,t+1}}\frac{\partial N^o_{jj,t+1}}{\partial V_{jj,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^r_{jj,t+1}}\frac{\partial N^r_{jj,t+1}}{\partial V_{jj,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^h_{jj,t+1}}\frac{\partial N^h_{jj,t+1}}{\partial V_{jj,t}}\right] + \lambda_{jj,t}q(\theta_{jj,t}) \\
0 &= -\kappa + \beta\left[\frac{\partial\mathcal{V}_{j,t+1}}{\partial N^o_{ji,t+1}}\frac{\partial N^o_{ji,t+1}}{\partial V_{ji,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^r_{ji,t+1}}\frac{\partial N^r_{ji,t+1}}{\partial V_{ji,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^h_{ji,t+1}}\frac{\partial N^h_{ji,t+1}}{\partial V_{ji,t}}\right] + \lambda_{ji,t}q(\theta_{ji,t})
\end{aligned}
$$

and,

$$
\begin{aligned}
\frac{\partial\mathcal{V}_{j,t}}{\partial N^o_{jj,t}} &= y_{jj,t} - \widetilde{w}^o_{jj,t} + \beta\left[\frac{\partial\mathcal{V}_{j,t+1}}{\partial N^o_{jj,t+1}}\frac{\partial N^o_{jj,t+1}}{\partial N^o_{jj,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^h_{jj,t+1}}\frac{\partial N^h_{jj,t+1}}{\partial N^o_{jj,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^r_{jj,t+1}}\frac{\partial N^r_{jj,t+1}}{\partial N^o_{jj,t}}\right] \\
\frac{\partial\mathcal{V}_{j,t}}{\partial N^h_{jj,t}} &= y_{jj,t} - \widetilde{w}^h_{jj,t} + \beta\left[\frac{\partial\mathcal{V}_{j,t+1}}{\partial N^o_{jj,t+1}}\frac{\partial N^o_{jj,t+1}}{\partial N^h_{jj,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^h_{jj,t+1}}\frac{\partial N^h_{jj,t+1}}{\partial N^h_{jj,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^r_{jj,t+1}}\frac{\partial N^r_{jj,t+1}}{\partial N^h_{jj,t}}\right] \\
\frac{\partial\mathcal{V}_{j,t}}{\partial N^r_{jj,t}} &= y_{jj,t} - \widetilde{w}^r_{jj,t} + \beta\left[\frac{\partial\mathcal{V}_{j,t+1}}{\partial N^o_{jj,t+1}}\frac{\partial N^o_{jj,t+1}}{\partial N^r_{jj,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^h_{jj,t+1}}\frac{\partial N^h_{jj,t+1}}{\partial N^r_{jj,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^r_{jj,t+1}}\frac{\partial N^r_{jj,t+1}}{\partial N^r_{jj,t}}\right] \\
\frac{\partial\mathcal{V}_{j,t}}{\partial N^o_{ji,t}} &= y_{ji,t} - \widetilde{w}^o_{ji,t} + \beta\left[\frac{\partial\mathcal{V}_{j,t+1}}{\partial N^o_{ji,t+1}}\frac{\partial N^o_{ji,t+1}}{\partial N^o_{ji,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^h_{ji,t+1}}\frac{\partial N^h_{ji,t+1}}{\partial N^o_{ji,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^r_{ji,t+1}}\frac{\partial N^r_{ji,t+1}}{\partial N^o_{ji,t}}\right] \\
\frac{\partial\mathcal{V}_{j,t}}{\partial N^h_{ji,t}} &= y_{ji,t} - \widetilde{w}^h_{ji,t} + \beta\left[\frac{\partial\mathcal{V}_{j,t+1}}{\partial N^o_{ji,t+1}}\frac{\partial N^o_{ji,t+1}}{\partial N^h_{ji,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^h_{ji,t+1}}\frac{\partial N^h_{ji,t+1}}{\partial N^h_{ji,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^r_{ji,t+1}}\frac{\partial N^r_{ji,t+1}}{\partial N^h_{ji,t}}\right] \\
\frac{\partial\mathcal{V}_{j,t}}{\partial N^r_{ji,t}} &= y_{ji,t} - \widetilde{w}^r_{ji,t} + \beta\left[\frac{\partial\mathcal{V}_{j,t+1}}{\partial N^o_{ji,t+1}}\frac{\partial N^o_{ji,t+1}}{\partial N^r_{ji,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^h_{ji,t+1}}\frac{\partial N^h_{ji,t+1}}{\partial N^r_{ji,t}} + \frac{\partial\mathcal{V}_{j,t+1}}{\partial N^r_{ji,t+1}}\frac{\partial N^r_{ji,t+1}}{\partial N^r_{ji,t}}\right]
\end{aligned}
$$

Noting $\widetilde{J}^e_{jj,t} = \frac{\partial \mathcal{V}_{j,t}}{\partial N^e_{jj,t}}$ with $\widetilde{J}^o_{jj,t} = \frac{\int_0^{\tau^{R_1}_{j,t}} J^o_{njj,t}(\tau)dF(\tau)}{F(\tau^{R_1}_{j,t})}$, $\widetilde{J}^h_{jj,t} = \frac{\int_{\tau^{R_1}_{j,t}}^{\tau^{R_2}_{j,t}} J^h_{njj,t}(\tau)dF(\tau)}{F(\tau^{R_2}_{j,t})-F(\tau^{R_1}_{j,t})}$, and $\widetilde{J}_{jj,t} = F(\tau^{R_1}_{j,t})\widetilde{J}^o_{jj,t} + \big(F(\tau^{R_2}_{j,t}) - F(\tau^{R_1}_{j,t})\big)\,\widetilde{J}^h_{jj,t} + \big(1 - F(\tau^{R_2}_{j,t})\big)\,\widetilde{J}^r_{jj,t}$, these FOCs of the firm's program lead to the following intertemporal job-creation conditions:

$$
\begin{aligned}
\frac{\kappa}{q(\theta_{jj,t})} - \lambda_{jj,t} &= \beta(1-s_j)\widetilde{J}_{jj,t+1} && (5)\\
\frac{\kappa}{q(\theta_{ji,t})} - \lambda_{ji,t} &= \beta(1-s_j)\widetilde{J}_{ji,t+1} && (6)
\end{aligned}
$$

$$
\begin{aligned}
\widetilde{J}^o_{jj,t} &= y_{jj,t} - \widetilde{w}^o_{jj,t} + \beta(1-s_j)\widetilde{J}_{jj,t+1} && (7)\\
\widetilde{J}^h_{jj,t} &= y_{jj,t} - \widetilde{w}^h_{jj,t} + \beta(1-s_j)\widetilde{J}_{jj,t+1} && (8)\\
\widetilde{J}^r_{jj,t} &= y_{jj,t} - \widetilde{w}^r_{jj,t} + \beta(1-s_j)\widetilde{J}_{jj,t+1} && (9)\\
\widetilde{J}^o_{ji,t} &= y_{ji,t} - \widetilde{w}^o_{ji,t} + \beta(1-s_j)\widetilde{J}_{ji,t+1} && (10)\\
\widetilde{J}^h_{ji,t} &= y_{ji,t} - \widetilde{w}^h_{ji,t} + \beta(1-s_j)\widetilde{J}_{ji,t+1} && (11)\\
\widetilde{J}^r_{ji,t} &= y_{ji,t} - \widetilde{w}^r_{ji,t} + \beta(1-s_j)\widetilde{J}_{ji,t+1} && (12)
\end{aligned}
$$

Leading to :

$$
\begin{aligned}
J^o_{n,jj,t}(\tau) &= y_{jj,t} - w^o_{n,jj,t}(\tau) + \beta(1-s_j)\widetilde{J}_{jj,t+1} && (13)\\
J^h_{n,jj,t}(\tau) &= y_{jj,t} - w^h_{n,jj,t}(\tau) + \beta(1-s_j)\widetilde{J}_{jj,t+1} && (14)\\
J^r_{jj,t} &= y_{jj,t} - w^r_{jj,t} + \beta(1-s_j)\widetilde{J}_{jj,t+1} && (15)\\
J^o_{n,ji,t}(\tau) &= y_{ji,t} - w^o_{n,ji,t}(\tau) + \beta(1-s_j)\widetilde{J}_{ji,t+1} && (16)\\
J^h_{n,ji,t}(\tau) &= y_{ji,t} - w^h_{n,ji,t}(\tau) + \beta(1-s_j)\widetilde{J}_{ji,t+1} && (17)\\
J^r_{ji,t} &= y_{ji,t} - w^r_{ji,t} + \beta(1-s_j)\widetilde{J}_{ji,t+1} && (18)
\end{aligned}
$$

2.4 Wage Bargaining

Wages are determined upon meeting with a simple Nash bargaining:

$$
\begin{aligned}
S^e_{n,jj,t} &= max_{w^e_{n,jj,t}}\{(max\{W^e_{n,jj,t} - U_{n,j,t}, 0\})^{\eta}(max\{J^e_{n,jj,t} - V_{jj,t}, 0\})^{(1-\eta)}\}\\
S^e_{n,ji,t} &= max_{w^e_{n,ji,t}}\{(max\{W^e_{n,ji,t} - U_{n,i,t}, 0\})^{\eta}(max\{J^e_{n,ji,t} - V_{ji,t}, 0\})^{(1-\eta)}\}
\end{aligned}
$$

Which gives the following :

$$\begin{aligned}
w^o_{n,jj,t}(\tau) &= \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1-f_{jj,t})\theta_{ij,t}\right] + (1-\eta)\left[c_{j,\tau}\tau_{n,j,t} + b\right] \\
w^h_{n,jj,t}(\tau) &= \begin{array}{l} \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1-f_{jj,t})\theta_{ij,t}\right] \\ +(1-\eta)\left[e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}} c_{j,\tau}\tau_{n,j,t} + f(1-e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}})\zeta_j + c_{h,j} + b\right] \end{array} \\
w^r_{jj,t} &= \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1-f_{jj,t})\theta_{ij,t}\right] + (1-\eta)\left[\zeta_j + b\right] \\
w^o_{n,ji,t}(\tau) &= \eta\left[y_{ji,t} + \kappa\theta_{ii,t} + \kappa(1-f_{ii,t})\theta_{ji,t}\right] + (1-\eta)\left[c_{i,\tau}\tau_{n,i,t} + b\right] \\
w^h_{n,ji,t}(\tau) &= \begin{array}{l} \eta\left[y_{ji,t} + \kappa\theta_{ji,t} + \kappa(1-f_{ii,t})\theta_{ji,t}\right] \\ +(1-\eta)\left[e^{-\frac{c_{j,\tau}\tau_{n,i,t}}{\zeta_i}} c_{i,\tau}\tau_{n,i,t} + f(1-e^{-\frac{c_{j,\tau}\tau_{n,i,t}}{\zeta_i}})\zeta_i + c_{h,j} + b\right] \end{array} \\
w^r_{ji,t} &= \eta\left[y_{ji,t} + \kappa\theta_{ii,t} + \kappa(1-f_{ii,t})\theta_{ji,t}\right] + (1-\eta)\left[\zeta_i + b\right]
\end{aligned}$$

2.5 Model Solutions

2.5.1 Condition to open a Vacancy

Regime 1 If the expectation of the average job value is sufficiently large to lead to $V_t > 0$, then $\lambda^f_t = 0$. In this case, the dynamics are given by :

$$\begin{aligned}
\frac{\kappa}{q(\theta_{jj,t})} - \lambda^f_{jj,t} &= \beta(1-s_j)\widetilde{J}_{jj,t+1} \\
\frac{\kappa}{q(\theta_{ji,t})} - \lambda^f_{ji,t} &= \beta(1-s_j)\widetilde{J}_{ji,t+1}
\end{aligned}$$

Regime 2 If the expectation of the average job value is sufficiently low leading to $V_t = 0$, then $\lambda^f_t > 0$. When $V_{j,t} = 0$, we have $\theta_t = 0 \equiv q(\theta_t) = 1$. Therefore the dynamics are given by:

$$\begin{aligned}
\lambda^f_{jj,t} &= \kappa - \beta(1-s_j)\widetilde{J}_{jj,t+1} \\
\lambda^f_{ji,t} &= \kappa - \beta(1-s_j)\widetilde{J}_{ji,t+1}
\end{aligned}$$

2.5.2 Choice between accepting On-site, Hybrid of Remote offer

Recall,

$$W^o_{n,jj,t}(\tau) - W^h_{n,jj,t}(\tau) = w^o_{n,jj,t}(\tau) - w^h_{n,jj,t}(\tau) - c_{j,\tau}\tau_{j,t} + e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}} c_{j,\tau}\tau_{n,j,t} + f(1-e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}})\zeta_j + c_{h,j}$$

$$W^r_{n,jj,t} - W^h_{n,jj,t}(\tau) = w^r_{jj,t} - w^h_{n,jj,t}(\tau) - \zeta_j + e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}} c_{j,\tau}\tau_{n,j,t} + f(1 - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}})\zeta_j + c_{h,j}$$

With, $\tau^{R_1}_{j,t}$ is a solution of

$$-c_{j,\tau}\tau^{R_1}_{j,t} + e^{-\frac{c_{j,\tau}\tau^{R_1}_{j,t}}{\zeta_j}} c_{j,\tau}\tau^{R_1}_{j,t} + f(1 - e^{-\frac{c_{j,\tau}\tau^{R_1}_{j,t}}{\zeta_j}})\zeta_j + c_{h,j} = 0 \tag{19}$$

and $\tau^{R_2}_{j,t}$ is a solution of

$$-\zeta_j + e^{-\frac{c_{j,\tau}\tau^{R_2}_{j,t}}{\zeta_j}} c_{j,\tau}\tau^{R_2}_{j,t} + f(1 - e^{-\frac{c_{j,\tau}\tau^{R_2}_{j,t}}{\zeta_j}})\zeta_j + c_{h,j} = 0 \tag{20}$$

3 Data

3.1 Parameters

The model parameters will be calibrated on data prior to the COVID-19 crisis. Hence, the calibration is set on data before 2018 the later included. The vector of parameters:

$$\Psi = \{\beta, \eta, b, \kappa, \mu, c_{\tau,u}, c_{\tau,r}, \mu_\tau, \sigma_\tau, \alpha_1, \alpha_2, \zeta_u, \zeta_r, c_{h,j}, s_u, s_r\},$$

u being for urban and r is for rural. Since we have little data on rural and urban zone, we will use data on educational attainment for unemployment rate, job separation rate, wages and remote work. This data will be linked to the one with the level of educational attainment in those two areas to build a data specific to each zone.

Usual Parameters: The time discount factor β is equal to $1/(1+0.0573)^{(1/12)}$ to match the mean discount rate in international data 5.73% per annum. The value of bargaining power is set to the mean bargaining power found in the literature. Hence $\eta = 0.5$.

3.2 Diploma

3.3 Wages

We have quarterly weekly wages data by educational attainment. To make it a monthly data we multiply it by 4.5 weeks which is the average number of weeks worked within a

	LHS	HS	Coll.	Bach.	Share of pop
Urban	10.6%	25.2%	29.8%	34.4%	84%
Rural	13.7%	33.2%	27.2%	25.9%	16%

Table 1: **Educational attainment for adults 25 and older Urban Vs Rural.** Source: U.S. Census Bureau's American Community Survey 2018.

month. Hence, using table 1 and 2 we can derive the median wage per zone (see table 3).

	LHS	HS	Coll.	Bach.
Median Wage	2009	2786	3209	4578

Table 2: **Median earning by educational attainment from 2000 to 2018.** Source : Weekly and hourly earnings data from the Current Population Survey BLS

	Median Wage
Urban	3446
Rural	3259

Table 3: **Median monthly earning Urban versus rural.**

3.4 Productivity

As stated before, there is a difference in productivity between urban and rural zone such that $y_{uu} = y_{rr}(1+\alpha_1)(1+\alpha_2)$ and $y_{ur} = y_{rr}(1+\alpha_1)$. The productivity difference between the two zones α_1 will be chosen so that

$$\{\frac{W_{urban}}{W_{rural}}\}_{data} = \{\frac{W_{urban}}{W_{rural}}\}_{model} = 1.057$$

.

3.5 Commuting parameters

3.5.1 Commuting Time and Distance

Using the American Community Survey 2018 for workers 16 years and over who did not work at home, we can produce the data on the daily commuting time in US. Figure 17 in Section 7.3 plots the estimation of a lognormal Pdf with $\mu_{\tau} = 3.3$ and $\sigma_{\tau} = 0.6$ which will be the calibration of the log normal law in the model.

3.5.2 Commuting Costs:

Following The Clever Real Estate, to account for commuting cost, 3 variables will be taken into account :

- Fuel: The monthly cost of fuel is estimated by dividing the distance to work ($i.e \;\; d$ per day which represent 42 miles[6]) by the average miles per gallon (50 to 60mpg). This will be multiplied by the number of business days in a month (19-22 business days) then by the average gas price per gallon (the average cost of gas in 2018: 2.91 \$ a gallon). In this case : $c_f = \frac{42}{55} \times 22 \times 2.91 = 49\$$
- Maintenance: The monthly cost of maintenance is the average cost of maintenance per mile (9 cents) multiplied by the average number of miles to work. $c_m = 0.09 \times 42 \times 22 = 83\$$
- Opportunity: We estimated the monthly opportunity cost of a person's time as the amount of money they could have earned had they been working instead of commuting by multiplying the average hourly wages in 2018 (14.99\$) by the number of hours spent commuting to work. $c_{op} = 22 \times 14.99 \times 27 \times 2/60 = 297\$$

On average the total monthly commute costs adds up to $c_{total} = c_f + c_m + c_{op} = 49 + 83 + 297 = 399\$$.

Recall, the average monthly wage in urban zone is 3446\$ while the average monthly wage in rural aera is 3259\$ Hence, $\{\frac{c_{\tau,u}\bar{\tau}}{\bar{w}_{urban}}\}_{model} = 11.58\%$ and $\{\frac{c_{\tau,r}\bar{\tau}}{\bar{w}_{rural}}\}_{model} = 12.24\%$. This gives us $c_{\tau,u}$ and $c_{\tau,r}$.

3.6 Working From Home

Using the the 2017-18 Leave and Job Flexibilities Module of the American Time, Dey et al. (2020) estimate that the percentage of workers who are able to work and did teleworker in the non metropolitan area's is about 3.4%, while this number is around 10% in metro

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[6] Assuming that typical car speed on residential roads or busy city roads is 50km/h and that the speed of vehicles on main road, travelling reasonably fast is between 80 and 90km/h. We take an average of speed of 75km/h. Then we can assume that the distance is $\bar{d} = 75 \times \tau \times \frac{2}{60} == 67.5km$

areas. We will then calibrate ζ_u and ζ_r so $(1 - F(\tau_u^{R_2})) + \bar{\lambda}_u(F(\tau_u^{R_2}) - F(\tau_u^{R_1})) = 0.1$ and $(1 - F(\tau_r^{R_2})) + \bar{\lambda}_r(F(\tau_r^{R_2}) - F(\tau_r^{R_1})) = 0.034$. Moreover, Pabilonia and Victoria (2022) use the same survey and divide teleworkers into two types: *(i)* home-based teleworkers, who work three or more days a week exclusively from home, and *(ii)* occasional teleworkers, who work exclusively at home at least once every two weeks but fewer than three days a week. Their sample consist of 65% of occasional teleworkers. We assume that $c_{h,j} = \alpha_h \zeta_j$ and will use this data to estimate α_h aiming at $\widetilde{\lambda} = 0.45$.

3.7 Flows

3.7.1 Unemployment, Job finding rate and Job separation rate

Aggregate data. The macro-level unemployment rate and job-separation rate data that we use are constructed from BLS data, from 2000 to 2018. Data pertaining to monthly employment and unemployment levels for all people aged 16 and over are seasonally adjusted. To construct worker flows following Adjemian et al. (2019), we use the number of unemployed workers who have been unemployed for less than five weeks. After dividing the unemployment levels in each month by the sum of unemployment and employment, we obtain monthly series for U_m (where m refers to the monthly frequency). We also have data on individuals unemployed for less than five weeks U_m^5 . We can then construct, the worker flows which is given by $JSR_m = \frac{U_{m+1} - U_{m+1}^5}{E_m}$.

Data by educational attainment. Using data from Cairo and Cajner (2016), we derive worker flows based on Current Population Survey (CPS) data (January 2000–January 2018)[7]. The first-order moments of worker flows used to identify the model parameters are shown in Table 4.

Rescaling method. To use both data sets, we first need to rescale them. We assume our aggregate data would remain unchanged. First, we construct the artificial macro-level unemployment rate (bur_t and $bjsr_t$) by using micro data ($ur_{s,t}$ and $jsr_{s,t}$) and the weight of each skill in the economy ω_s: $bur_t = \sum_{s=1}^{S} \omega_s ur_{s,t}$ and $bjsr_t = \sum_{s=1}^{S} \omega_s jsr_{s,t}$. We then calculate the coefficient of rescaling x^i such that$x_{s,t}^1 = ur_{s,t}/bur_t$, and $x_{s,t}^2 = jsr_{s,t}/bjsr_t$. Second, we reconstruct the micro data to match the macro data (UR and JSR): $hur_{s,t} =$

---

[7] They construct the number of short-term unemployed individuals (i.e., unemployed for fewer than five weeks) for each education group; doing so allowed them to calculate the job-finding and separation rates for each diploma level

	LHS	HS	Coll.	Bach.	Aggregate
JSR	0.0367	0.0204	0.0169	0.0095	0.0184
UR	0.1059	0.0677	0.0566	0.0333	0.0600
Share of population	0.11	0.33	0.31	0.25	1

Table 4: **Worker flows and stocks.** Data came from Cairo and Cajner (2016) and cover the 2000–2014 period; we rescaled these data. For population shares, the data came from the BLS and cover the 2000–2018 period. The educational attainment typologies are as follows: less that high school diploma (LHS), high school diploma (HS), college diploma (Coll.) and bachelor degree or more (Bach.).

$x^1_{s,t}UR_t$, and $hjsr_{s,t} = x^2_{s,t}JSR_t$. Finally, to test our estimation, we calculate the macro data using the rescaled micro data: $hbur_t = \sum_{s=1}^{S} \omega_s hur_{s,t}$ and $hbjsr_t = \sum_{s=1}^{S} \omega_s hjsr_{s,t}$; we then compare these data to the original data (UR, JFR, and JSR). We find that the rescaling matches the data well (see figure 18 in Section 7.3).

Flow by areas Combining Table 1 and 4 we have the following

	Urban	Rural
JSR	0.0173	0.0189
UR	0.0566	0.0610

Table 5: **Job flows Urban Versus Rural.**

3.7.2 Worker Flow between Rural and Urban Areas

To identify the workers flow between the residing area and the working one we cross-file between two datasets[8]: *(i)* The first one indicate the Residence County to Workplace County Flows for the United States 2011-2015 5-Year ACS Commuting Flows while *(ii)* the second indicate the Percentage of the total population of the county represented by the urban population in 2010. We can hence build a dataset indicating the number of flows for the four different possibilities: *(i)* From Urban to Urban *(ii)* From Urban to Rural *(iii)* From Rural to Urban *(iv)* From Rural to Rural. Table 6 presents an example of the crossfiled informations. From this table we can conclude that the number of workers working and residing in an urbanized area $N_{UU} = 40 \times 0.2298 \times 0.5772$.

We can therefore summarize the information in Table 7. We find that the share of urban

---

[8] Both series are from United State Census Bureau.

County of Residence	County of Work	Workers flow	% urban in RC	% urban in WC
Baldwin	Orleans	40	57.72	22.98

Table 6: **An example of workers flow between two counties Urban Versus Rural.**

workers on total workers is 84% and that the share of workers residing in urban zone and working in rural zone is only 11% which is not counterfactual.

	p_{RU}	p_U
Value	0.11	0.84

Table 7: **Workers flows from Working County to Residence County.** $p_{RU} = \frac{N_{RU}}{N_{UU}+N_{RU}}$ and $p_U = \frac{N_{UU}+N_{UR}}{N_{Total}}$

Identification: Using table 5 we identify $s_u = 0.0173$, $s_r = 0.0189$ and for the remaining parameters

$$\Psi = \{b, \alpha_2, \kappa, \mu\},$$

we use both moments from table 5 and table 7

$$\Phi = \{\{UR_{z,t}, p_{RU}, p_U\}\},$$

with $dim(\Psi) = dim(\Phi) = 4$ We search Ψ, which minimizes the root mean square error for each time series in Φ.

3.8 Calibration

First, it appears that the gaps between the targeted and simulated moments are overly reasonable. The value of the opportunity cost of employment b is 0.2 which is lower than the calibration found in the literature however it is within the range of 18% to 60% of the average wage. Moreover, in this framework workers are not only compensated for their outside option (unemployment) they are also compensated for their commuting costs or their disutility of doing remote work. Once those two parameters are taken into account, the total benefits that a worker can bargain for rang from 0.28 to 0.72. The cost of opening a vacancy is set to 0.2 which is close to the 20% of the expected present value of the lifetime wage. The elasticity of the matching function ($\mu = 0.35$) is close to the value used by Petrosky-Nadeau and Zhang (2017) (0.407), however, it is significantly lower than

Parameters	Value
Time discount factor β	0.995
Wage Bargaining power η	0.5
Job Separation rate in urban s_u	0.0173
Job Separation in rural s_r	0.0189
Productivity of workers living in rural area and working in rural area y_{rr}	1
Average commuting time μ_τ	3.3
Standard deviation of commuting time σ_τ	0.6

Table 8: **Parameter Using external information.**

the value obtained by Den Haan et al. (2000) (1.27). The productivity differences between urban and areas firms and workers are respectively 0.095 and 0.07 meaning that the urban firms (workers) are more productive (qualified) than the rural ones which is supported by the data.

The estimation of the model also shows that the disutility of doing remote work is higher for rural workers than urban ones. This reflects the fact that teleworking can be challenging for workers who do not have access to the necessary technology and equipment. In fact, urban areas tend to have more infrastructure and resources that support remote work, such as high-speed internet, coworking spaces, and other amenities that makes it easier for workers to work from home or other remote locations. Moreover, rural areas tend to have more agriculture and manufacturing jobs that may require physical presence and face-to-face interactions.

Parameters	Value	Moments	Data	Model
The value of unemployment activities b	0.20	UR_{urban}	0.057	0.059
Productivity difference for urban workers α_2	0.07	UR_{rural}	0.061	0.062
Productivity difference for urban firm α_1	0.095	$\frac{W_{urban}}{W_{rural}}$	1.057	1.070
The fixed cost of vacancy posting κ	0.2	p_U	0.841	0.868
Elasticity of the matching function μ	0.35	p_{RU}	0.106	0.134
Commuting costs in urban $c_{\tau,u}$	0.0034	$\frac{c_{\tau,u}\bar{\tau}}{\bar{w}_{urban}}$	0.116	0.081
Commuting costs in rural $c_{\tau,r}$	0.004	$\frac{c_{\tau,r}\bar{\tau}}{\bar{w}_{rural}}$	0.122	0.131
Disutility of commuting ζ_u	0.32	Share of remote workers	0.1	0.096
Disutility of commuting ζ_r	0.52	Share of remote workers	0.034	0.038
Hybrid costs α_h	0.1	$\bar{\lambda}$	0.45	0.48

Table 9: **Model's Calibration, Target and Simulated Moments.**

Urban Versus Rural : The steady-state results, in table 10 show that urban workers are always better off whether they work in urban or rural area compared to the rural workers. Moreover, working in the urban area is always the best option for the two types of workers as the wages are higher in this area due the higher productivity. This will in it turn increase the job finding rate in this area making the rural one less attractive which creates a congestion effect and makes the vacancy harder to be filled in urban areas. Furthermore, we can see that the job finding rate of urban workers in rural areas is higher than the rural workers in their residing area. This is due to the fact that their high qualification levels makes urban residents more profitable and hence more attractive to the firm.

	Vacancy filling rate	Job finding rate	wages
Work Urban-live Urban	0.068	0.243	1.106
Work Rural-live Urban	0.321	0.041	1.055
Work Rural-live Rural	0.336	0.038	0.987
Work Urban-live Rural	0.072	0.234	1.033

Table 10: **Model Result.**

On-site, Hybrid and remote : Table 11 presents the findings that employees who work remotely or have hybrid work arrangements tend to earn higher wages than those who work exclusively in a traditional office setting. The reason for this trend can be traced back to the Pre-COVID era when remote work was less prevalent and perceived as risky. Workers had concerns about the challenges and isolation that could arise from working remotely, leading to a higher perceived disutility. To compensate for this disutility, employees demanded higher wages.

	$\bar{W}_u$	$\bar{W}_r$
On-site	1.060	1.012
Hybrid	1.136	1.087
Remote	1.222	1.172

Table 11: **Model Result.**

4 Model Simulation

According to a study by Barrero et al. (2020), it is estimated that after the pandemic ends, 20% of full workdays will be supplied from home. This increase in remote work is attributed to a number of factors, including better-than-expected remote working experiences, investments in physical and human capital that facilitate remote work, reduced stigma associated with remote work, concerns about crowds and contagion risks, and a pandemic-driven surge in technological innovations that support remote work. In fact, data from the 2021 American Community Survey (ACS) shows that between 2019 and 2021, the number of people primarily working from home tripled from 5.7% to 17.9%, which represents a 12.2 percentage point increase. This shift in working from home is the focus of this paper, which aims to *(i)* explain the factors contributing to this increase, *(ii)* examine the effects of this increase on labor market outcomes, and *(iii)* introduce a public policy given the shifts in the economy.

4.1 Post COVID-19 Economy

We consider three main shifts in the model : *(i)* The disutility of working from home, *(ii)* the increase in commuting costs, and *(iii)* the increase in remote workers productivity.

The disutility of remote work : The parameter ζ, the disutility of remote work, could be one of the factors explaining the main shifts cited by Barrero et al. (2020). In fact, we have stated that before COVID-19 crisis, that remote work was less prevalent as it was perceived as risky. However, with the onset of the pandemic, remote work became more widespread and workers became accustomed to the practice, reducing the perceived disutility associated with remote work.

If we where to estimate the expenses of a remote worker we should take into account technology expenses (as computers, software, internet...), work spaces expenses (desk, chair, office supplies..) and communication expenses (video conferencing software subscription, phone bills). For work-spaces and communication expenses, as there was a high demand of those furniture we can expect that the prices may have increased due to supply chain disruptions and increased demand, which in it turn should increase the disutility of remote work and hence increase ζ which goes in the opposite direction as our assumption. Using BLS data of CPI Computers, peripherals, and smart home assistants in U.S. city average for all urban consumers we compute the variation in the technology expenses which is around 5% decrease based on the 2007=100 price index. Hence, we multiply ζ_1 , ζ_2 with a scaling parameter with $\zeta_1^{'} = \delta \times \zeta_1$ and $\zeta_2^{'} = \delta \times \zeta_2$. If we assume that ζ captures this shift in technology expenses then $\delta = 0.95$.

Commuting costs : Due to the current crisis, the model should take into account all the other element that may influence the workers decision to choose between teleworking or working on site. Equations 1-3 show that for higher commuting costs, workers are less willing to commute and work on site. The change in this parameter should influence future outcomes. In fact, the fuel prices rose from an average of 2.91$ in 2018 to 4.04$ in 2022 according to the US Department of Energy . In this model, it is is equivalent to an increase of commuting cost by 12.5% [9]. Hence, in the new economy $c_{\tau}^{'} = c_{\tau} \times 1.125$.

Remote workers' productivity : There is an ongoing debate regarding whether remote workers experience an increase or decrease in productivity. While some studies suggest that remote workers benefit from reduced commuting time and costs, greater flexibility and autonomy, improved working conditions, and a better work-life balance resulting in higher job satisfaction and motivation, others argue that the difficulties in separating work and personal life, lack of social interaction and support, and challenges in collaborating with colleagues or accessing necessary resources can lead to decreased productivity while working from home [10].

In this paper, following the 2022 Survey of Working Arrangements and Attitudes[11], we also assume an increase in productivity for remote workers. In fact, in this survey, respondents use the saved commuting time in 40% into extra work, 19.7% into indoor leisure, 16.2% into chores at home and the remaining into outdoor leisure and childcare. If we establish as the Fair Labor Standards Act (FLSA) that the standard workday is 8 hours (40 hours a week), and if we estimate that remote workers save approximately 1 hour in commuting per day (27 minutes per round trip), and that they use 40% of this saved hours working at home, hence this estimates that remote workers are 4.5% more productive.

Shifts in the model's parameters : As stated before, we will study the impact of this three shifts on the model. Hence in the new benchmark, we have : $\zeta_1^{'} = 0.95 \times \zeta_1$,

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[9] The monthly cost of fuel will become $c_f = 69$\$ making the average monthly commuting costs to $c_{total} = 449$, which represent an increase of 12.5%.

[10] See Natalia Emanuel and Harrington (2021), Bloom et al. (2015), Choudhury et al. (2021), Etheridge et al. (2020) and Gibbs et al. (2021) for both sides of arguments

[11] See SWAA, Barrero et al. (2020)

$\zeta_2^{'} = 0.95 \times \zeta_2$, $c_{\tau}^{'} = c_{\tau} \times 1.125$ and, $y^r = y^o \times (1 + \alpha_r)$, with $\alpha_r = 4.5\% \times 0.95$ which will change the two values of $\tau_{j,t}^{R_1}$ and $\tau_{j,t}^{R_2}$ [12]. Moreover, for simplicity, we assume that hybrid workers gain half of the increase of remote workers productivity leading to $y^h = y^o \times (1 + \frac{\alpha_r}{2})$.

4.2 Results

Figure 1 is divided into three panels. It depicts the effect of varying δ for the new level of commuting costs ($c_{\tau}^{\prime} = 1.125 \times c_{\tau}$) and the proportional increase in productivity ($\alpha_r = 0.045 \times \delta$). For $\delta = 0.95$, the economy is at it Post-COVID Benchmark. Panel *a* shows that the proportion of remote workers decreases as the disutility of teleworking, denoted as ζ, increases. This means that when the disutility of teleworking decreases, the relative value of working remotely increases compared to working on-site. At a $\zeta = 0$ level, the value of working remotely (as determined by Equation 3) depends only on the worker's wage. Meanwhile, the value of working on-site (as determined by Equation 1) becomes less appealing, as workers still incur commuting costs. Therefore, workers tend to choose remote work more frequently when the disutility of teleworking is lower. Moreover, Panel *b* of the same figure shows that the share of remote work during hybrid work arrangements, denoted as λ, is also a decreasing function of ζ for similar reasons as those in Panel *a*. However, in Panel *c*, the total share of hybrid workers in the economy is a non-monotonic function that initially increases and then decreases, with a maximum at around $\delta = 0.35$, on average. This is because when the disutility of teleworking is low enough, workers tend to prefer fully remote work instead of a hybrid arrangement. Conversely, when the disutility of teleworking is high enough, workers tend to prefer fully on-site work instead of a hybrid arrangement. Therefore, the share of hybrid workers is highest at an intermediate level of the disutility of teleworking. Finally, panel *a* also reveals that for the new parameters values $\delta = 0.95$, $y^r = y^o \times (1+\alpha_r)$, $y^h = y^o \times (1+\frac{\alpha_r}{2})$ and $c_{\tau}^{'} = c_{\tau} \times 1.125$, the new share of remote workers is 20.30%, which represents the 20 percent of full workdays estimated by Barrero et al. (2020) but slightly overestimate the 12.2 percentage points increase by 1.4 percentage point.

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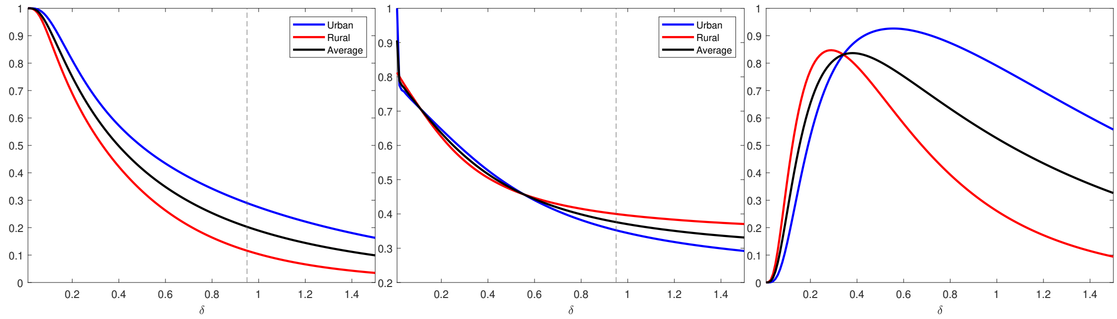
[12] α_r is scaled by the level of heterogeneity between on-site and remote workers, denoted as δ. It is important to note that as δ approaches zero, the heterogeneity between this two type of workers also decreases, as every worker chooses to work remotely. Since α_r is a measure of the difference between these two states, it should decrease as the level of heterogeneity between them decreases.



(a) Share of remote workers (b) Remoters in hybrid set-up (c) Share of hybrid workers

Figure 1: **Share of remote workers as a function of ζ**

Labor Market outcomes, comparison with the Pre-COVID economy : We compare the labor market outcomes from the Pre-COVID crisis to the Post-COVID economy in 2022, where the disutility of remote work decreased, commuting costs increased, and the productivity of remote workers increased while assuming that there is no other exogenous factors that may impact the labor market. Table 12 presents the main changes in the labor market outcomes, and we investigate how each parameter shift influences the labor outcomes by allowing one parameter at a time to remain unchanged.

We find that compared to the Pre-COVID period, the benchmark unemployment rate in urban and rural areas has increased slightly. This is mainly due to the fact that the increased commuting costs have increased the bargained wages of remote workers and made them less profitable for firms. In column (3) of the table, where there is no increase in commuting costs, we observe that if the economy experiences only a shift in productivity and disutility of remote work, the unemployment rate would have decreased while wages would have increased. Moreover, the increase in commuting costs explains only a small portion of the increase in the share of remote work, while nearly half of the shift in the share of remote workers is explained by the change in remote worker productivity (see column (5)).

Additionally, in column (4) of the table, where only the disutility of remote workers did not change, we find that the decrease in disutility has slightly dampened the negative effect of the increased commuting costs on the unemployment rate, but this shift of parameter only explains a small increase in the share of remote workers. Furthermore, in column (5) of the table, where the increase in productivity of remote workers is set at 0, we observe that the drop in unemployment rate would have been slightly higher if the increase in productivity of remote workers did not occur.

In conclusion, the main increase in unemployment rate between the Pre-COVID economy and the Post-COVID one is mainly due to the high commuting costs. This increase is dampened mainly by the increase in remote workers' productivity, which is further reinforced by the decrease in worker disutility, as a higher share of remote workers are now present in the economy with a higher productivity, making them more profitable for firms. Our findings highlight the importance of considering the interplay between productivity, commuting costs, and worker disutility when analyzing the labor market outcomes in a Post-COVID economy. Moreover, if the price of fuel continues to rise, public policy may not have much influence on worker productivity or on the disutility of remote worker. However, two policies can stick out, a policy encouraging the increase of remote work or one subsidzing commuting costs. To further understand the impact of remote worker disutility on labor outcomes, we will examine its effect on the benchmark economy in the next section.

	Pre-COVID	Post-COVID			
	(1)	Benchmark (2)	$\Delta c_\tau = 0$ (3)	$\Delta\zeta = 0$ (4)	$\alpha_r = 0$ (5)
U_U	0.0589	0.0594	0.0588	0.0595	0.0596
U_R	0.0616	0.0627	0.0615	0.0627	0.0628
U	0.0603	0.0611	0.0602	0.0612	0.0612
w_U	1.0991	1.1198	1.1176	1.1203	1.0998
w_R	1.0271	1.0349	1.0322	1.0346	1.0283
Share of remote	0.0671	0.2030	0.1719	0.1892	0.1030

Table 12: **Understanding The shift in the labor market.**

4.3 The effect of Remote Workers Disutility

In the benchmark economy, we have seen that the increase in commuting costs has had a significant impact on labor market outcomes, leading to a slight increase in unemployment rates in both urban and rural areas. However, this negative effect is partially offset by the increase in remote worker productivity and the decrease in remote worker disutility. Specifically, the increase in remote worker productivity has contributed to a higher share of remote workers in the economy, making them more profitable to firms and helping to mitigate the negative impact of higher commuting costs on labor outcomes. Additionally, the decrease in remote worker disutility has slightly dampened the negative effect of increased commuting costs on unemployment rates. Therefore, policy interventions that has as a consequence reducing the disutility of remote workers could be beneficial in mitigating the negative effects of rising fuel prices on labor market outcomes. By making remote work more attractive, it can lead to a more efficient allocation of labor and potentially reduce the negative impact of higher commuting costs on labor outcomes.

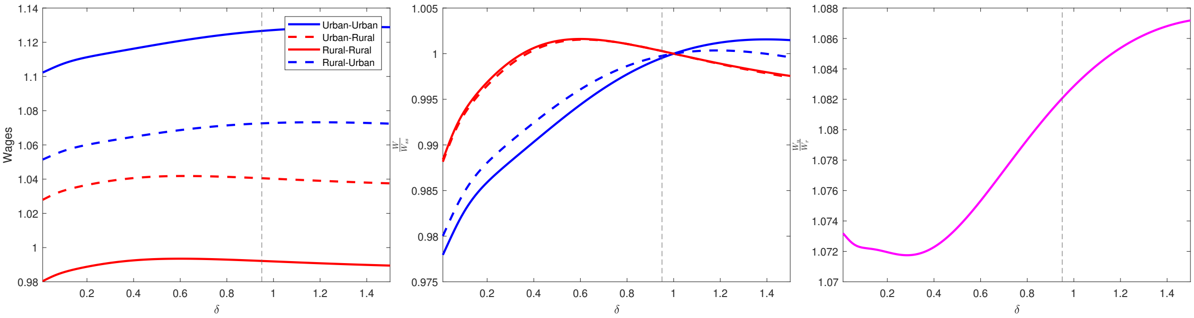
To analyse how this parameter influence the outcome of this model, we multiply ζ_1 , ζ_2 with a scaling parameter in the benchmark case and see how the the model will evolve. Hence, we have now $\zeta_1' = \delta \times \zeta_1$ and $\zeta_2' = \delta \times \zeta_2$ with $\delta = [0; 1.5]$.

Wages : Alexandre and Pallais (2017) conduct a large-scale randomized control trial for a national call center and find that workers are willing to accept a 6-8% reduction in wages to work from home. In the same spirit, Aksoy et al. (2022) show that employees value the option of working from home 2-3 days per week at 5 percent of pay on average. This model features the same trend. In fact, Figure 2 presents several interesting findings related to wages for both urban and rural workers in the benchmark economy. Panel (a) shows that, overall, wages for urban workers are higher than for rural workers. However, panel (b) shows that as δ decreases, wages for urban workers decrease more rapidly than for rural workers. Interestingly, wages for rural workers actually increase for intermediate values of δ in the range of 0.35 to 1, while urban wages continue to decrease. However, for values of δ below 0.35, wages for both rural and urban workers decrease. Hence, as in Alexandre and Pallais (2017) and Aksoy et al. (2022), workers are willing to accept lower wages to work from home.

To understand these findings, we disentangle the two parts that constitute wages in the model. The first part is driven by market tightness, while the second part depends on factors such as disutility of remote work and job type (on-site, hybrid, or fully remote). Figure 4 shows that there are two contradictory mechanisms at play. On one hand, as δ decreases and workers become more profitable due to their high levels of remote productivity, the first part of wages also increases (panel *(a)* and *(b)*). On the other hand, as the disutility of remote work decreases, the second part of wages decreases (panel *(c)* and *(d)*).

The total effect on wages observed in Figure 2 can be explained as follows. For urban workers, the effect of the decreased disutility in the second part of wages outweighs the increase in worker profitability, resulting in an overall decrease in wages. For rural workers, the effect is more complex. For intermediate values of δ (0.35 to 1), the effect of worker profitability dominates and wages increase. However, for values of δ below 0.35, the effect is driven by lower worker disutility, resulting in lower wages for both rural and urban workers.

Finally, in Panel c of Figure 2, it is shown that the wage gap between urban and rural workers decreases as δ decreases, while the unemployment gap between the two areas also decreases (as seen in Panel c of Figure 5).

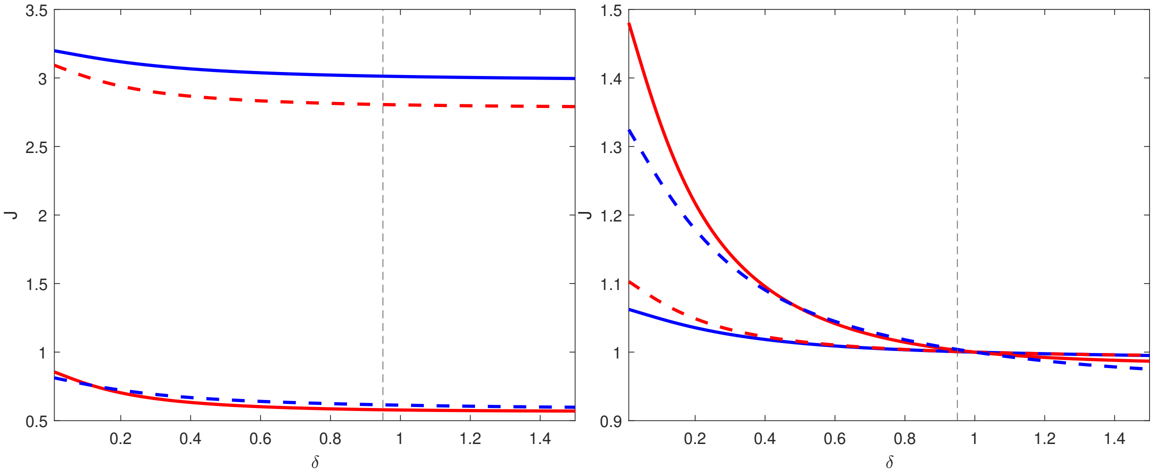


(a) In levels

(b) Relative to $\delta = 1$

(c) Wage in urban relative to rural

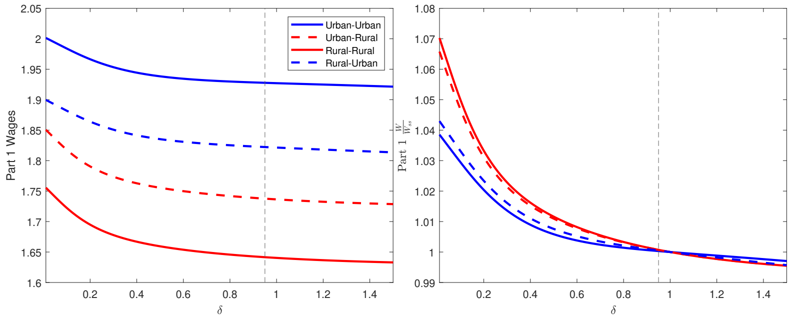
Figure 2: **Wages as a function of ζ**



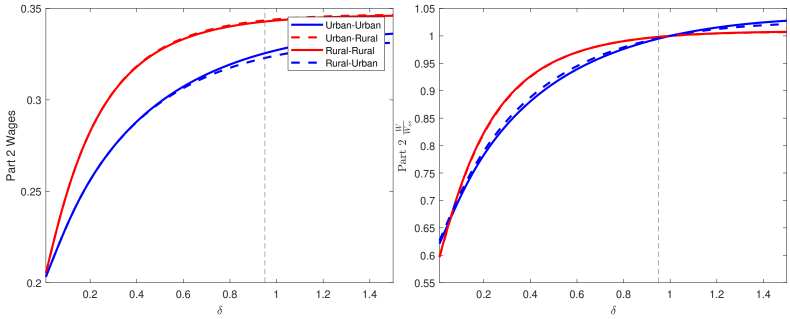
(a) In levels

(b) Relative to $\delta = 1$

Figure 3: **Firm's Profits as a function of ζ**



(a) In levels (b) Relative to $\delta = 1$

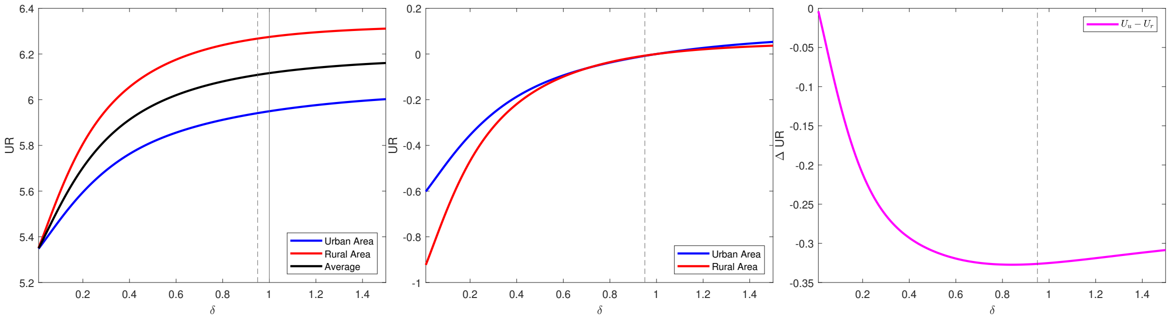


(c) In levels (d) Relative to $\delta = 1$

Figure 4: **Disentangling wages ζ**

Unemployment rate: Figure 5 displays that unemployment rate increases as the disutility of teleworking, driven by δ, increases. For the lowest values of δ, unemployment rates in both urban and rural areas are at their lowest points and are at the same level, standing at 5.35%. On one hand, this is because for low levels of disutility, workers are willing to bargain for lower wages in exchange of working remotely, (see in Figure 2). On the other hand, as the disutility of remote workers decreases, the share of this type of workers increases and with it the overall profitability (as productivity of remote workers is high). The speed decline in unemployment rate through the decline of δ is more pronounced for rural workers than urban one as they become relatively more profitable compared to the case where $\delta = 1$ see panel *(b)* of Figure 3. This in it turn decreases the unemployment gap between both areas.

In this section, we further show that if the disutility of remote work is sufficiently low, this negative effect can be fully absorbed. Specifically, we find that for values of δ equal to or lower than 0.6, the negative effect of commuting costs is entirely absorbed, compared to the Pre-COVID case. Therefore, one might argue that reducing the disutility of remote work could potentially eliminate the need for increasing remote workers' productivity to mitigate the negative shock of commuting costs.



(a) In levels (b) Relative to $\delta = 1$ (c) Comparing the the two areas

Figure 5: **Unemployment rate as a function of ζ**

In the next section, we will compare four different scenarios to further explore this idea. The first scenario only considers the reduction of workers' disutility, the second scenario includes the effect of commuting costs, the third scenario adds high remote productivity for remote workers (our benchmark), and the fourth scenario eliminates the impact of commuting costs entirely. By comparing the results of these scenarios, we can gain a better understanding of the relative importance of each factor in mitigating the negative impact of commuting costs on the labor market.

4.4 Is the Decrease in Remote Worker's Disutility Enough?

First, as shown in Figure 6, increasing commuting costs leads to a higher share of remote workers (case 2 compared to case 1). This is because as the cost of commuting is now relatively higher, working from home seems a more attractive option for workers. Moreover, when productivity of remote workers also increases, as in the benchmark case (case 3), this share of remote workers is even higher. This is because workers are now able to bargain for higher wages due to their increased productivity, making remote work an even more attractive option. As a result, the drop in disutility needed to convince workers to switch from on-site work to fully remote or hybrid setting does not need to be very high. Case 4 shows that the effect of a higher remote worker productivity on the share of remote workers is higher than the effect of the commuting costs.

Second, Panel *a* of Figure 7 illustrates that when only remote productivity is higher (case 4), unemployment rate levels are significantly lower compared to the benchmark case. This is because higher remote productivity increases the profitability and attractiveness of remote workers to firms, resulting in higher demand for remote workers. Furthermore, commuting costs have a substantial impact on unemployment rates (case 2), and the effect

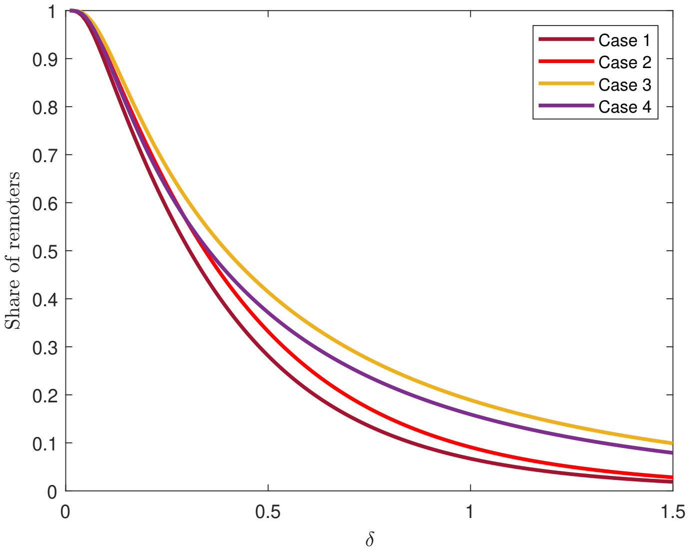
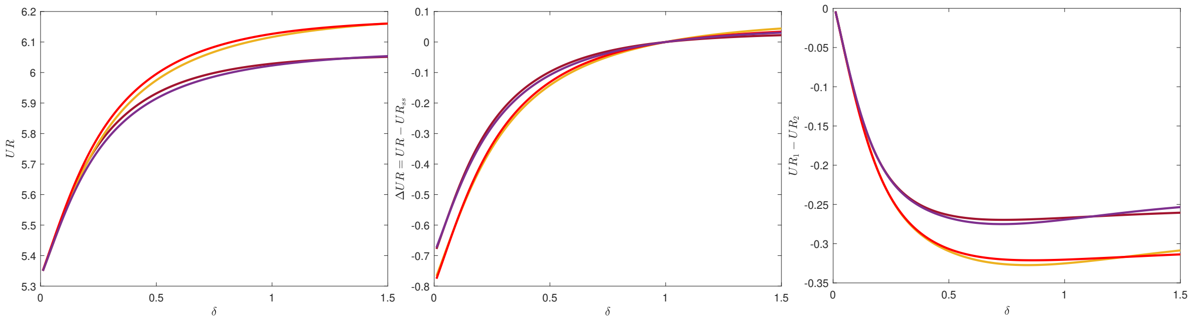


Figure 6: **Share of remote workers as a function of ζ**. Case 1: only ζ moves, Case 2: Case1 + higher commuting costs, Case 3: Case 2 + higher remote workers productivity (Benchmark at $\delta = 0.95$) and Case 4 : Case 1 + higher remote workers productivity only.

is dampened with higher remote workers' productivity (case 3). As shown in Figure 6, workers are incentivized to work remotely more often, which leads to a higher share of workers with higher productivity, increases firms' profits, and subsequently increases the employment rate. However, for intermediate values of δ, the increase in unemployment rate due to higher commuting costs in case 2 is neither absorbed by the decrease of ζ nor by the increase of remote workers productivity.

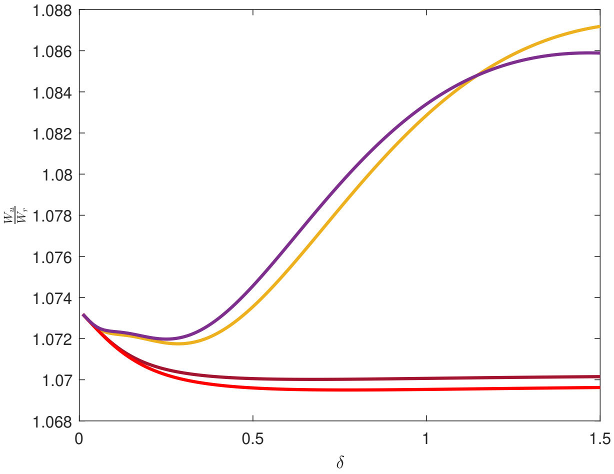
It is not feasible to have 100% of remote work in the economy as most jobs are not entirely remotable. Therefore, this result highlights the fact even if public policy focuses on subsidising working from home, it is crucial to acknowledge that further increases in commuting costs could still harm workers in both urban and rural areas.

Finally, findings from Figure 8 demonstrate that with higher commuting costs only (case 2), wage inequalities between urban and rural areas are slightly lower. This is because rural workers bargain for higher commuting costs, making their wages more comparable to urban workers. However, in case 3 and 4 where remote workers have higher productivity levels, wage inequalities increase as urban workers now not only bargain for their initial high productivity (due to higher qualifications and technology) but also benefit from high remote productivity (as they have initially a higher share of remote workers). Nevertheless, the disparities between urban and rural wages tend to decrease in case 3 and join the levels of the other two cases. This suggests that for very low values of $\delta \leq 0.5$, the increase in remote workers' productivity coupled with low level of workers' disutlity not only compensates for the high increase in commuting costs but can also decrease unemployment inequalities for comparable (yet higher) level of wage inequalities as the Pre-COVID economy. Therefore, reducing the disutility of remote work, up to a reasonable point, does not eliminate the need for increasing remote workers' productivity to mitigate the negative shock of commuting costs.



(a) UR (b) UR relative to the steady state (c) $UR_u - UR_r$

Figure 7: **Unemployment rate in the three cases**

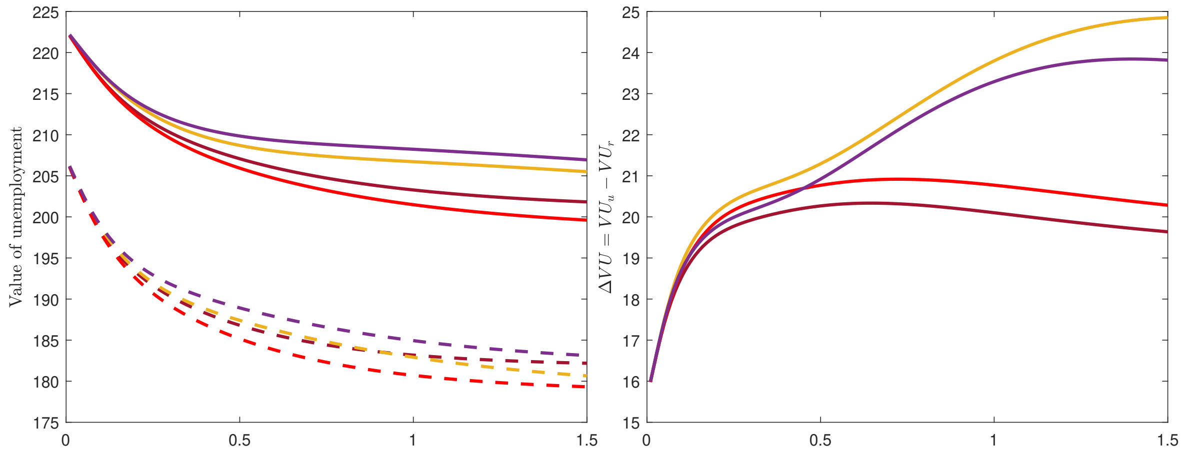


(a)

Figure 8: **Wages inequalities in the three cases**

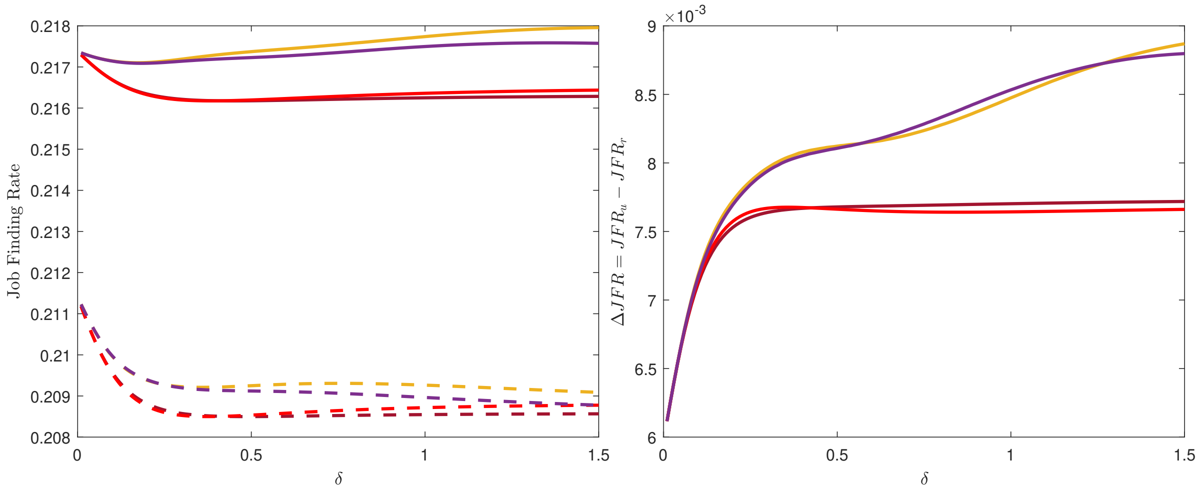
4.5 A Win-Win Situation? The Effect of Remote Work Disutility on the Well-being of Unemployed Workers and the Wealth of the Economy

Where are unemployed workers better off? In his book Pissarides (2020), the author argues that measuring the well-being of society should not be based solely on economic growth or the welfare of those who are employed. Instead, he emphasizes the importance of considering the welfare of those who are unemployed. To evaluate the impact of inequalities of the different cases, we examine the value of unemployed workers in each scenario. As depicted in Panel (a) of Figure 9, unemployed workers are better off when remote productivity is high and if they are residing in the urban area. This can be attributed to the fact that rural workers experience a large gap in job finding rates, given the initial productivity differences between them and their urban counterparts (i.e., when $\delta = 1$) as shown in Figure 10. However, it is also in those cases that the inequalities between the two zones are at their highest (Panel (b) of Figure 9). As stated before, this is because for $\delta = 1$, there are initially more remote workers in urban areas compared to rural areas, a further increase in remote productivity leads to increased demand for remote workers in urban areas, making them more attractive to firms. Consequently, the job-finding rate in urban areas is higher than in rural areas, leading to higher inequalities between the two zones. Nevertheless, as the value of δ decreases, not only the well-being of unemployed workers increases but also with it a decrease in the disparities between the two regions. Thus, the higher productivity of remote workers is only beneficial, for unemployed well being, if the disutility of remote work is sufficiently low to attract a significant number of remote workers in both areas.



(a) In levels (b) $\delta VU = VU_u - VU_r$

Figure 9: **Measuring the well-being of unemployed workers** The plane lines for urban areas and the dotted one for rural areas



(a) In levels (b) δJFR

Figure 10: **Job Finding rate**

Measuring Economic Wealth : It is also interesting to see, how the wealth in the two areas evolve depending on the different cases. We measure wealth as the net production produced in each area :

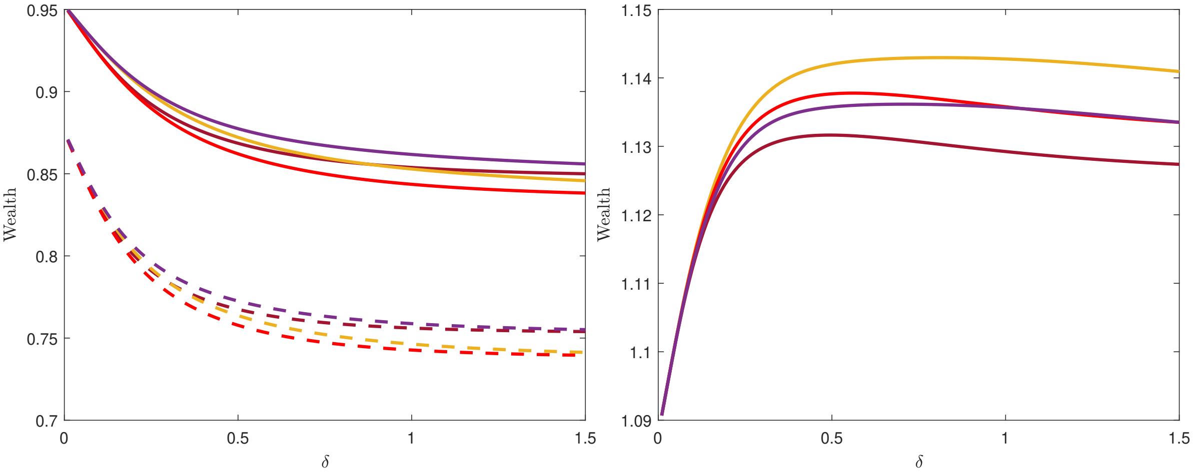
$$Wealth_j = \sum_I y_{ij} - \sum_I p_{ij} \times \left(F_{ij}^o \times \widetilde{\tau}_j{}^o + F_{ij}^h \times (1 - \widetilde{\lambda}_{ij}) \times \widetilde{\tau}_j{}^h \right) \times c_{j,\tau} - \sum_I p_{ij} \times \left(F_{ij}^r + F_{ij}^h \times \widetilde{\lambda}_{ij} \right) \times \zeta_j - \kappa$$

with $p_{ij} = \frac{N_{ij}}{N_{ij}+N_{jj}}$.

In Figure 11, Panel *(a)* demonstrates that decreasing disutility among remote workers leads to an increase in overall wealth in both regions. This is due to two factors: the direct reduction of remote disutility and the indirect effect on total commuting costs in the economy. As disutility of working from home decreases, the proportion of on-site workers decreases, resulting in fewer people commuting and incurring those costs.

However, Panel *(b)* of the same figure shows that for intermediate values of δ, this decrease in disutility results in greater divergence in wealth, with urban zones being favored. This is because firms in urban zones benefit not only from higher technology and qualifications but also from a higher proportion of remote workers. Therefore, both the costs of commuting and working from home decrease more rapidly in the urban economy for intermediate values of δ. Only when δ reaches very low values does the rural zone begin to catch up.

The analysis on the well-being of the unemployed and economic wealth highlights the benefits of reducing remote work disutility. It results in a win-win situation by improving the well-being of the unemployed and reducing the well-being gap between rural and urban areas. Additionally, it increases overall wealth in both economies. However, the reduction in disutility only narrows the wealth gap between the two zones for low values of remote work disutility.



(a) In levels (b) Wealth of urban relative to rural economy

Figure 11: **Wealth**

5 Policy

As we have previously seen, the increase in commuting costs has led to a slight increase in the unemployment rate in the Post-COVID economy. However, this increase is mitigated by the higher productivity of remote workers, which is further strengthened by the decrease in worker disutility. In the light of the continuous increase in commuting costs, two public policies can be proposed to address this issue: *(i)* funding the increase in commuting costs or *(ii)* subsidizing remote workers through a tax that affects all workers equally and is proportional to their wages. However, we have also found that for intermediate values of δ, the increase in unemployment rate due to higher commuting costs cannot be offset by either the decrease in ζ or the increase in remote workers' productivity. Since it is not feasible to have all jobs fully remote, we focus on a public policy in this section that aims to fund the increase in commuting costs in the benchmark model Post-COVID crisis, where there are changes such as $c'_\tau = c_\tau \times 1.125$, $\zeta' = 0.95 \times \zeta$, and $\alpha_r = 0.045 \times 0.95$. This will enable us to measure the extent to which this policy improves the labor market outcomes.

Section 7.4 illustrates how the model's equations change when a tax s_w is introduced. The primary difference is that negotiated wages will increase for all workers, even those who are not the primary beneficiaries of the subsidy, since they all contribute to repaying the tax. The negotiated wages will thus be:

$$\begin{aligned}
w^o_{n,jj,t}(\tau) &= \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1 - f_{jj,t})\theta_{ij,t}\right] + \frac{1-\eta}{1-s_w}\left[c_{j,\tau}\tau_{n,j,t} + b\right] \\
w^h_{n,jj,t}(\tau) &= \begin{array}{l} \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1 - f_{jj,t})\theta_{ij,t}\right] \\ +\tfrac{1-\eta}{1-s_w}\left[e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}} c_{j,\tau}\tau_{n,j,t} + f(1 - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}})\zeta_j + c_{h,j} + b\right] \end{array} \\
w^r_{jj,t} &= \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1 - f_{jj,t})\theta_{ij,t}\right] + \frac{1-\eta}{1-s_w}\left[\zeta_j + b\right] \\
w^o_{n,ji,t}(\tau) &= \eta\left[y_{ji,t} + \kappa\theta_{ii,t} + \kappa(1 - f_{ii,t})\theta_{ji,t}\right] + \frac{1-\eta}{1-s_w}\left[c_{i,\tau}\tau_{n,i,t} + b\right] \\
w^h_{n,ji,t}(\tau) &= \begin{array}{l} \eta\left[y_{ji,t} + \kappa\theta_{ji,t} + \kappa(1 - f_{ii,t})\theta_{ji,t}\right] \\ +\tfrac{1-\eta}{1-s_w}\left[e^{-\frac{c_{j,\tau}\tau_{n,i,t}}{\zeta_i}} c_{i,\tau}\tau_{n,i,t} + f(1 - e^{-\frac{c_{j,\tau}\tau_{n,i,t}}{\zeta_i}})\zeta_i + c_{h,j} + b\right] \end{array} \\
w^r_{ji,t} &= \eta\left[y_{ji,t} + \kappa\theta_{ii,t} + \kappa(1 - f_{ii,t})\theta_{ji,t}\right] + \frac{1-\eta}{1-s_w}\left[\zeta_i + b\right]
\end{aligned}$$

Setting the subsidy : If commuting costs increases, the effect on the economy is proportional to the number of commuter in this economy. Hence, the total cost in the economy is :

$$cost = \sum_I \sum_J p_{ij} \times \left(F^o_{ij} \times \widetilde{\tau_j}^o + F^h_{ij} \times (1 - \widetilde{\lambda}_j) \times \widetilde{\tau_j}^h \right) \times c_{j,\tau}$$

With, $p_{ij} = \frac{N_{ij}}{\sum_I \sum_J N_{ij}}$.

if $c_{j,\tau}$ increases, such that the new commuting cost is $c'_{j,\tau} = c_{j,\tau} \times (1 + \gamma)$, the subsidy is computed given the quantities in the economy without any shocks, the new costs is :

$$cost' = \sum_I \sum_J p_{ij} \times \left(F^o_{ij} \times \widetilde{\tau_j}^o + F^h_{ij} \times (1 - \widetilde{\lambda}_{ij}) \times \widetilde{\tau_j}^h \right) \times c'_{j,\tau}$$

Hence, proportional taxes are :

$$\Delta cost = cost' - cost = \sum_I \sum_J p_{ij} \times \left(F^o_{ij} \times \widetilde{\tau_j}^o + F^h_{ij} \times (1 - \widetilde{\lambda}_{ij}) \times \widetilde{\tau_j}^h \right) \times \gamma$$

This cost is payed such that :

$$s_w \times w_{total} = \Delta cost$$

with $w_{total} = \sum_I \sum_J p_{ij} \times \left(F^o_{ij} \times w^o_{ij} + F^h_{ij} \times w^h_{ij} + F^r_{ij} \times w^r_{ij} \right)$

Results: As discussed earlier, due to the rise in commuting costs between the Pre-COVID and Post-COVID economy, the value of γ is set to 0.125. The results of this policy change are presented in Table 13. It shows that compared to the benchmark in the Post-COVID economy, subsidizing commuting costs has reduced the decline in the unemployment rate in the two areas by lowering wages. However, despite this improvement, the unemployment rates are still higher than the Pre-COVID levels. Additionally, implementing this policy has led to a 3 point percentage decrease in the proportion of remote workers, resulting in a decrease in the number of remote workers benefiting from the increased productivity.

Figure 12 demonstrates that as commuting costs continue to increase, taxes will also increase proportionally with commuting subsidies. The percentage of wages that will be deducted due to taxes is approximately 9% for an increase in commuting costs of up to 100%. This increase in subsidies can have a dual effect on wages: *(i)* increasing wages as workers demand higher wages to cover the taxes and *(ii)* decreasing wages as the share of the firm's profit decreases.

Panel (c) of Figure 13 reveals that the subsidy is a viable option up to an increase of 48% in commuting costs for rural areas, while for urban zones, it is only a feasible option up

	Pre-COVID	Post-COVID	
	(1)	Benchmark (2)	c_τ subsidies (3)
U_U	0.0589	0.0594	0.0590
U_R	0.0616	0.0627	0.0618
U	0.0603	0.0611	0.0604
w_U	1.0991	1.1198	1.1176
w_R	1.0271	1.0349	1.0324
Share of remote	0.0671	0.2030	0.1704
s_w	0	0	1.1%

Table 13: **The effect of commuting costs subsidies.**

to an increase of 37%. The average for the economy is 42%. However, Figures 14 and 15 indicate that this subsidy has a negligible impact on the well-being of unemployed workers and the wealth of the economy. Nevertheless, the fact that this subsidy can improve the Post-COVID benchmark up to an increase of 42% is a positive signal.

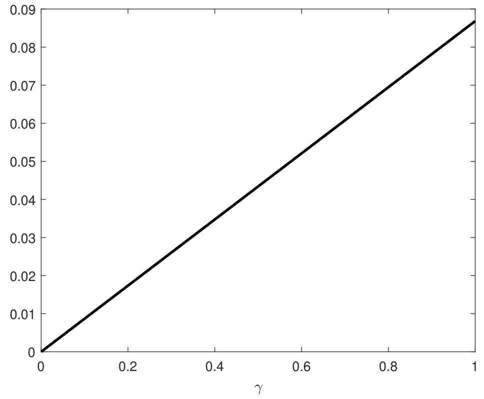
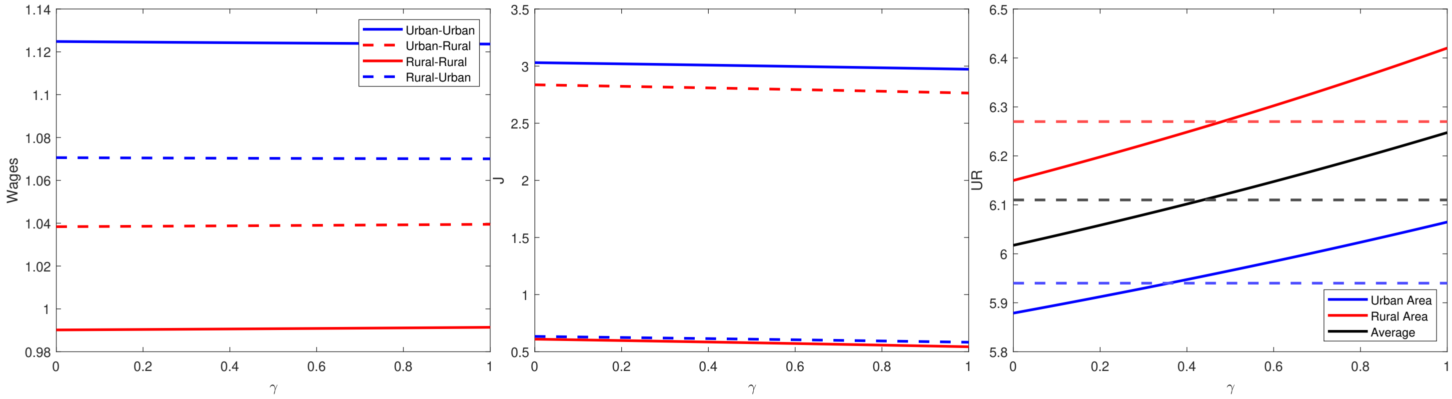
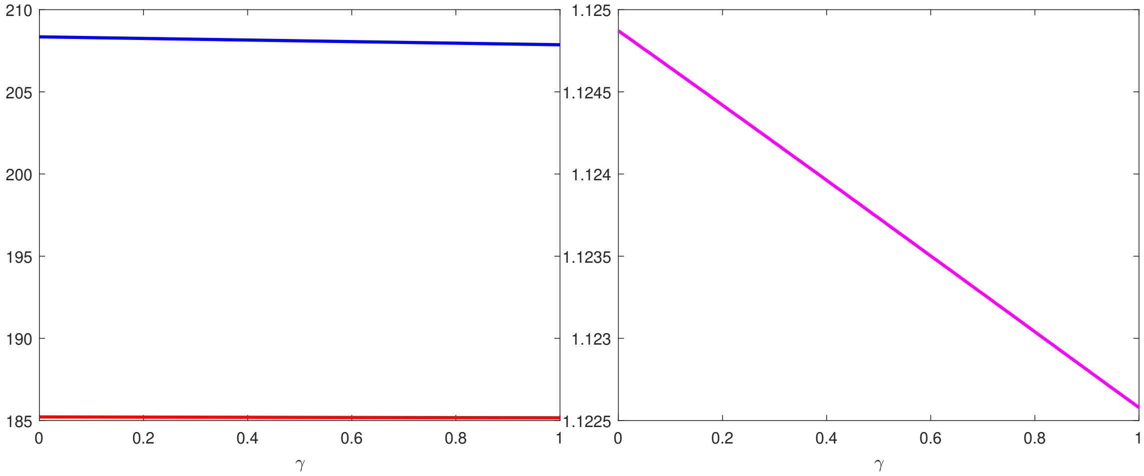


Figure 12: **Proportional taxes s_w as a function of γ**



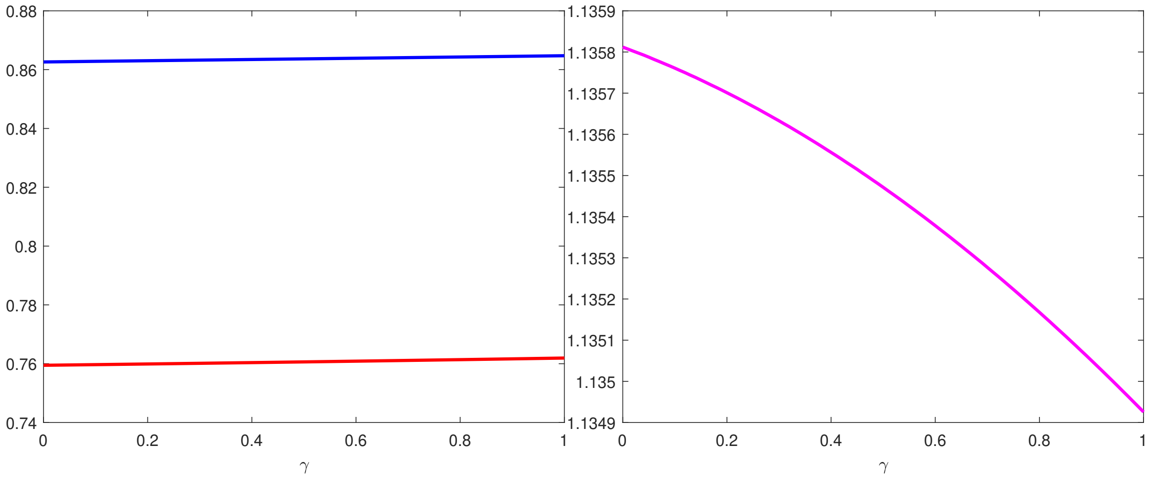
(a) Wages (b) Job Value (c) Unemployment rate

Figure 13: **The effect of the increase commuting costs and the subsidy on labour outcomes**



(a) In levels (b) $\delta VU = VU_u - VU_r$

Figure 14: **Unemployed Workers' Well-being**



(a) In levels

(b) Urban wealth relative to the rural one

Figure 15: **Wealth**

6 Conclusion

This study examines the impact of the new working from home trend on labour market outcomes, using a structural model that incorporates shifts in working from home disutility, commuting costs, and remote workers' productivity. Our analysis shows that the increase in commuting costs has led to a slight increase in the unemployment rate in both urban and rural areas, which has been partially offset by the increase in remote workers' productivity and the decrease in worker disutility. However, we find that reducing the disutility of remote work alone is not enough to fully absorb the negative impact of increased commuting costs. Nevertheless, reducing remote work disutility results in a win-win situation by improving the well-being of the unemployed, narrowing the well-being gap between rural and urban areas, and increasing overall wealth in both economies.

In addition, we demonstrate that a public policy that funds the increase in commuting costs through a tax proportional to workers' wages is a valuable option up to an increase of 42% in commuting costs, on average. This work opens up the field on the potential for working from home or anywhere to alleviate rural-urban migration patterns while improving labour market outcomes, which could be explored in future research using this structural model.

7 Appendix

7.1 Model

$$W^o_{n,ij,t}(\tau) \quad = \quad w^o_{n,ij,t}(\tau) - c_{j,\tau}\tau_{n,j,t} + \beta \begin{bmatrix} (1-s_i)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{n,ij,t+1}(\tau)dF(\tau) \\ +(1-s_i)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,ij,t+1}(\tau)dF(\tau) \\ +(1-s_i)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{n,ij,t+1}(\tau)dF(\tau) \\ +s_iU_{i,t+1} \end{bmatrix} \tag{21}$$

$$W^h_{ij,t}(\tau) \quad = \quad w^h_{n,ij,t}(\tau) - (1-\lambda_{n,j,t})c_{j,\tau}\tau_{n,j,t} - f(\lambda_{n,j,t})\zeta_j - c_{h,j} + \beta \begin{bmatrix} (1-s_i)\int_0^{\tau^{R}_{j,t+1}} W^o_{ij,t+1}(\tau)dF(\tau) \\ +(1-s_i)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{ij,t+1}(\tau)dF(\tau) \\ +(1-s_i)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{ij,t+1}(\tau)dF(\tau) \\ +s_iU_{i,t+1} \end{bmatrix} \tag*{(2}$$

$$W^r_{n,ij,t}(\tau) \quad = \quad w^r_{n,ij,t} - \zeta_j + \beta \begin{bmatrix} (1-s_i)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{n,ij,t+1}(\tau)dF(\tau) \\ +(1-s_i)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,ij,t+1}(\tau)dF(\tau) \\ +(1-s_i)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{n,ij,t+1}(\tau)dF(\tau) \\ +s_iU_{i,t+1} \end{bmatrix} \tag{23}$$

7.2 Steady state

Nothing $\widetilde{\tau}_j = \frac{\int_0^{\tau_{nj,t}^{R_1}} \tau_{nj,t} dF(\tau)}{F(\tau_{j,t}^{R_1})}$ and $\widetilde{\lambda}_j = E\left[\lambda^*_{n,j,t} | \tau_{n,j,t} \in [\tau_{j,t}^{R_1}; \tau_{j,t}^{R_2}]\right]$, the steady state is given by

$$\begin{aligned}
\widetilde{w}^o_{jj} &= \eta\left[y_{jj} + \kappa\theta_{jj} + \kappa(1-f_{jj})\theta_{ij}\right] + (1-\eta)\left[c_{j,\tau}\widetilde{\tau}^o_j + b\right] && (24)\\
\widetilde{w}^h_{jj} &= \eta\left[y_{jj} + \kappa\theta_{jj} + \kappa(1-f_{jj})\theta_{ij}\right] + (1-\eta)\left[(1-\widetilde{\lambda}_j)c_{j,\tau}\widetilde{\tau}^h_j + f(\widetilde{\lambda}_j)\zeta_j + c_{h,j} + b\right] && (25)\\
\widetilde{w}^r_{jj} &= \eta\left[y_{jj} + \kappa\theta_{jj} + \kappa(1-f_{jj})\theta_{ij}\right] + (1-\eta)\left[\zeta_j + b\right] && (26)\\
\widetilde{w}^o_{ji} &= \eta\left[y_{ji} + \kappa\theta_{ii} + \kappa(1-f_{ii})\theta_{ji}\right] + (1-\eta)\left[c_{i,\tau}\widetilde{\tau}^o_i + b\right] && (27)\\
\widetilde{w}^h_{ji} &= \eta\left[y_{ji} + \kappa\theta_{ii} + \kappa(1-f_{ii})\theta_{ji}\right] + (1-\eta)\left[(1-\widetilde{\lambda}_i)c_{i,\tau}\widetilde{\tau}^h_i + f(\widetilde{\lambda}_j)\zeta_i + c_{h,i} + b\right] && (28)\\
\widetilde{w}^r_{ji} &= \eta\left[y_{ji} + \kappa\theta_{ii} + \kappa(1-f_{ii})\theta_{ji}\right] + (1-\eta)\left[\zeta_i + b\right] && (29)\\
\widetilde{J}_{jj} &= \frac{F(\tau_j^{R_1})\left[y_{jj} - \widetilde{w}^o_{jj}\right] + \left(F(\tau_j^{R_2}) - F(\tau_j^{R_1})\right)\left[y_{jj} - \widetilde{w}^h_{jj}\right] + \left(1 - F(\tau_j^{R_2})\right)\left[y_{jj} - \widetilde{w}^r_{jj}\right]}{1-\beta(1-s_j)} && (30)\\
q(\theta_{jj}) &= \frac{\kappa}{\beta(1-s_j)\widetilde{J}_{jj}} && (31)\\
\theta_{jj} &= (q_{jj}^{-\mu} - 1)^{1/\mu} && (32)\\
\widetilde{J}_{ji} &= \frac{F(\tau_i^{R_1})\left[y_{ji} - \widetilde{w}^o_{ji}\right] + \left(F(\tau_i^{R_2}) - F(\tau_i^{R_1})\right)\left[y_{ji} - \widetilde{w}^h_{ji}\right] + \left(1 - F(\tau_i^{R_2})\right)\left[y_{ji} - \widetilde{w}^r_{ji}\right]}{1-\beta(1-s_j)} && (33)\\
q(\theta_{ji}) &= \frac{\kappa}{\beta(1-s_j)\widetilde{J}_{ji}} && (34)\\
\theta_{ji} &= (q_{ji}^{-\mu} - 1)^{1/\mu} && (35)
\end{aligned}$$

Finally using $U_i = 1 - N_{ii} - N_{ji}$ and $U_j = 1 - N_{jj} - N_{ij}$, we solve for employment using :

$$\begin{aligned}
N_{jj} &= (1-s_j)\left[N_{jj} + q(\theta_{jj})V_{jj}\right]\\
N_{ji} &= (1-s_j)\left[N_{ji} + q(\theta_{ji})V_{ji}\right]\\
N_{ii} &= (1-s_i)\left[N_{ii} + q(\theta_{ii})V_{ii}\right]\\
N_{ij} &= (1-s_i)\left[N_{ij} + q(\theta_{ij})V_{ij}\right]
\end{aligned}$$

7.3 Data

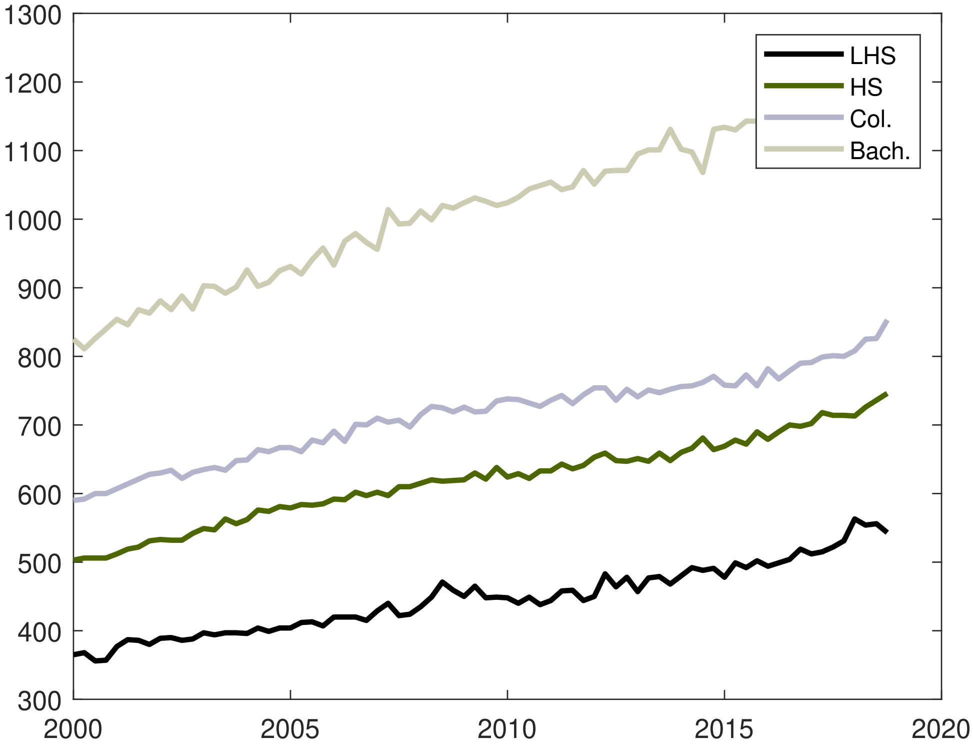


Figure 16: **Quarterly Weekly Wages**

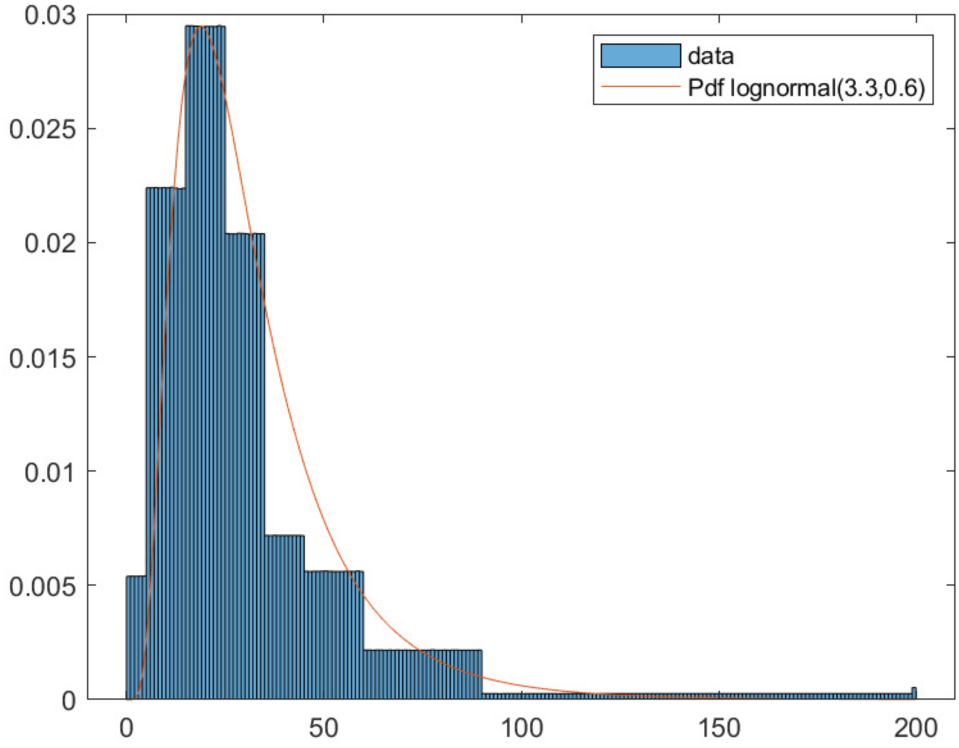
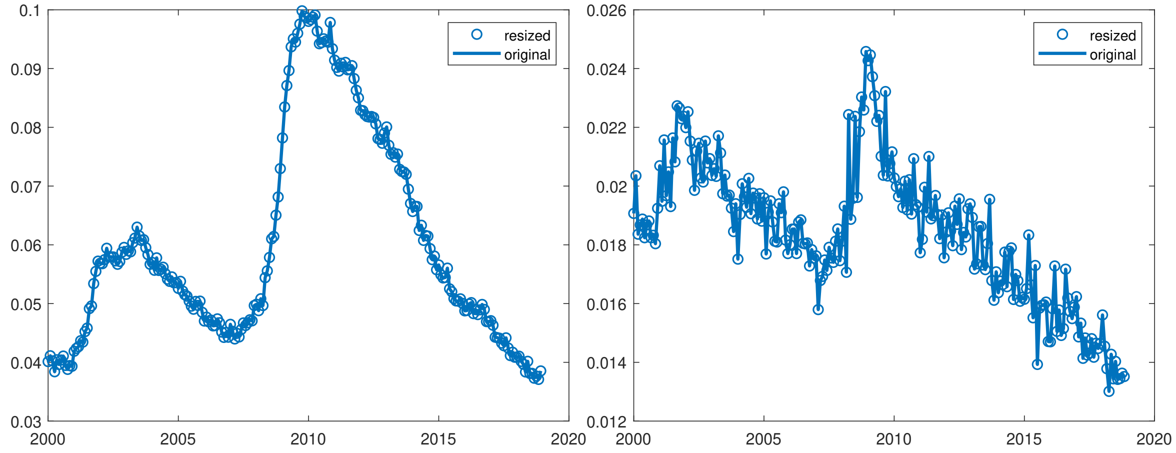


Figure 17: **Commuting time estimation in US**



(a) UR (b) JSR

Figure 18: **Unemployment and Job separation rate data**

7.4 Model with subsidies

7.4.1 Workers

$$W^o_{n,jj,t}(\tau) = (1-s_w)w^o_{n,jj,t}(\tau) - c_{j,\tau}\tau_{n,j,t} + \beta \begin{bmatrix} (1-s_j)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{n,jj,t+1}(\tau)dF(\tau) \\ +s_jU_{n,j,t+1} \end{bmatrix} \tag{36}$$

$$W^h_{n,jj,t}(\tau) = \begin{array}{l} (1-s_w)w^h_{n,jj,t}(\tau) - (1-\lambda_{n,j,t})c_{j,\tau}\tau_{n,j,t} - f(\lambda_{n,j,t})\zeta_j - c_{h,j} \\ +\beta \begin{bmatrix} (1-s_j)\int_0^{\tau^{R}_{j,t+1}} W^o_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R}_{j,t+1}}^{\tau^{max}} W^r_{n,jj,t+1}(\tau)dF(\tau) \\ +s_jU_{j,t+1} \end{bmatrix} \end{array} \tag{37}$$

$$W^r_{n,jj,t} = (1-s_w)w^r_{n,jj,t} - \zeta_j + \beta \begin{bmatrix} (1-s_j)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^h_{n,jj,t+1}(\tau)dF(\tau) \\ +(1-s_j)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{n,jj,t+1}(\tau)dF(\tau) \\ +s_jU_{n,j,t+1} \end{bmatrix} \tag{38}$$

$$U_{j,t} = b + \beta \begin{bmatrix} f_{jj,t}(1-s_j)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{jj,t+1}(\tau)dF(\tau) \\ +f_{jj,t}(1-s_j)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^r_{jj,t+1}(\tau)dF(\tau) \\ +f_{jj,t}(1-s_j)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^h_{jj,t+1}(\tau)dF(\tau) \\ +f_{ij,t}(1-f_{jj,t})(1-s_i)\int_0^{\tau^{R_1}_{j,t+1}} W^o_{ij,t+1}(\tau)dF(\tau) \\ +f_{ij,t}(1-f_{jj,t})(1-s_i)\int_{\tau^{R_1}_{j,t+1}}^{\tau^{R_2}_{j,t+1}} W^r_{ij,t+1}(\tau)dF(\tau) \\ +f_{ij,t}(1-f_{jj,t})(1-s_i)\int_{\tau^{R_2}_{j,t+1}}^{\tau^{max}} W^r_{ij,t+1}(\tau)dF(\tau) \\ +f_{jj}s_jU_{j,t+1} \\ +f_{ij}(1-f_{jj,t})s_iU_{j,t+1} \\ +(1-f_{ij,t})(1-f_{jj,t})U_{j,t+1} \end{bmatrix},$$

The optimal remote frequency in the hybrid sitting remain unchanged $\frac{\partial W^h_{n,jj,t}}{\partial \lambda_t} = 0$, leading to :

$$\lambda^*_{n,j,t} = 1 - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}}$$

7.5 Firm:

The firm's problem remains the same :

$$\begin{aligned}
\mathcal{V}_{j,t}(N_{j,t}) \quad &= \max_{V_{jj,t},V_{ji,t},N^o_{jj,t},N^r_{jj,t},N^h_{jj,t},N^o_{ji,t},N^r_{ji,t},N^h_{ji,t}} D_{j,t} + \beta\mathcal{V}_{j,t+1}(N_{j,t+1}) \\
\text{s.t} \quad &\left\{ \begin{array}{rcl}
 & & y_{jj,t}(N^o_{jj,t} + N^r_{jj,t} + N^h_{jj,t}) + y_{ji,t}(N^o_{ji,t} + N^r_{ji,t} + N^h_{ji,t}) \\
D_{j,t} & = & -\widetilde{w}^o_{jj,t}N^o_{jj,t} - \widetilde{w}^r_{jj,t}N^r_{jj,t} - \widetilde{w}^h_{jj,t}N^h_{jj,t} - \widetilde{w}^o_{ji,t}N^o_{ji,t} - \widetilde{w}^r_{ji,t}N^r_{ji,t} - \widetilde{w}^h_{ji,t}N^h_{jj,t} \\
 & & -\kappa V_{jj,t} - \kappa V_{ji,t} \\
N^o_{jj,t} & = & (1-s_j)F(\tau^{R_1}_{jj,t})[N^o_{jj,t-1} + N^h_{jj,t-1} + N^r_{jj,t-1} + q(\theta_{jj,t-1})V_{jj,t-1}] \\
N^h_{jj,t} & = & (1-s_j)\left(F(\tau^{R_2}_{jj,t} - F(\tau^{R_1}_{jj,t})\right)[N^o_{jj,t-1} + N^h_{jj,t-1} + N^r_{jj,t-1} + q(\theta_{jj,t-1})V_{jj,t-1} \\
N^r_{jj,t} & = & (1-s_j)\left(1 - F(\tau^{R_2}_{jj,t})\right)[N^o_{jj,t-1} + N^h_{jj,t-1} + N^r_{jj,t-1} + q(\theta_{jj,t-1})V_{jj,t-1}] \\
N^o_{ji,t} & = & (1-s_j)F(\tau^{R_1}_{ji,t})[N^o_{ji,t-1} + N^h_{ji,t-1} + N^r_{ji,t-1} + q(\theta_{ji,t-1})V_{ji,t-1}] \\
N^h_{ji,t} & = & (1-s_j)\left(F(\tau^{R_2}_{ji,t}) - F(\tau^{R_1}_{ji,t})\right)[N^o_{ji,t-1} + N^h_{ji,t-1} + N^r_{ji,t-1} + q(\theta_{ji,t-1})V_{ji,t-1} \\
N^r_{ji,t} & = & (1-s_j)\left(1 - F(\tau^{R_2}_{ji,t})\right)[N^o_{ji,t-1} + N^h_{ji,t-1} + N^r_{ji,t-1} + q(\theta_{ji,t-1})V_{ji,t-1}] \\
q(\theta_{jj,t})V_{jj,t} & \geq & 0 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (\lambda^f_{jj,t}) \\
q(\theta_{ji,t})V_{ji,t} & \geq & 0 \qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad (\lambda^f_{ji,t})
\end{array} \right.
\end{aligned}$$

Leading to :

$$\begin{aligned}
\frac{\kappa}{q(\theta_{jj,t})} - \lambda_{jj,t} &= \beta(1-s_j)\widetilde{J}_{jj,t+1} \qquad (39) \\
\frac{\kappa}{q(\theta_{ji,t})} - \lambda_{ji,t} &= \beta(1-s_j)\widetilde{J}_{ji,t+1} \qquad (40)
\end{aligned}$$

and,

$$\begin{aligned}
J^o_{n,jj,t}(\tau) &= y_{jj,t} - w^o_{n,jj,t}(\tau) + \beta(1-s_j)\widetilde{J}_{jj,t+1} \qquad (41) \\
J^h_{n,jj,t}(\tau) &= y_{jj,t} - w^h_{n,jj,t}(\tau) + \beta(1-s_j)\widetilde{J}_{jj,t+1} \qquad (42) \\
J^r_{jj,t} &= y_{jj,t} - w^r_{jj,t} + \beta(1-s_j)\widetilde{J}_{jj,t+1} \qquad (43) \\
J^o_{n,ji,t}(\tau) &= y_{ji,t} - w^o_{n,ji,t}(\tau) + \beta(1-s_j)\widetilde{J}_{ji,t+1} \qquad (44) \\
J^h_{n,ji,t}(\tau) &= y_{ji,t} - w^h_{n,ji,t}(\tau) + \beta(1-s_j)\widetilde{J}_{ji,t+1} \qquad (45) \\
J^r_{ji,t} &= y_{ji,t} - w^r_{ji,t} + \beta(1-s_j)\widetilde{J}_{ji,t+1} \qquad (46)
\end{aligned}$$

7.6 Wage Bargaining

Wages are determined upon meeting with a simple Nash bargaining:

$$S^e_{n,jj,t} = max_{w^e_{n,jj,t}}\{(max\{W^e_{n,jj,t} - U_{n,j,t}, 0\})^{\eta}(max\{J^e_{n,jj,t} - V_{jj,t}, 0\})^{(1-\eta)}\}$$
$$S^e_{n,ji,t} = max_{w^e_{n,ji,t}}\{(max\{W^e_{n,ji,t} - U_{n,i,t}, 0\})^{\eta}(max\{J^e_{n,ji,t} - V_{ji,t}, 0\})^{(1-\eta)}\}$$

Which gives the following :

$$\begin{aligned}
w^o_{n,jj,t}(\tau) &= \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1 - f_{jj,t})\theta_{ij,t}\right] + \frac{1-\eta}{1-s_w}\left[c_{j,\tau}\tau_{n,j,t} + b\right] \\
w^h_{n,jj,t}(\tau) &= \begin{array}{l} \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1 - f_{jj,t})\theta_{ij,t}\right] \\ +\frac{1-\eta}{1-s_w}\left[e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}}c_{j,\tau}\tau_{n,j,t} + f(1 - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}})\zeta_j + c_{h,j} + b\right] \end{array} \\
w^r_{jj,t} &= \eta\left[y_{jj,t} + \kappa\theta_{jj,t} + \kappa(1 - f_{jj,t})\theta_{ij,t}\right] + \frac{1-\eta}{1-s_w}\left[\zeta_j + b\right] \\
w^o_{n,ji,t}(\tau) &= \eta\left[y_{ji,t} + \kappa\theta_{ii,t} + \kappa(1 - f_{ii,t})\theta_{ji,t}\right] + \frac{1-\eta}{1-s_w}\left[c_{i,\tau}\tau_{n,i,t} + b\right] \\
w^h_{n,ji,t}(\tau) &= \begin{array}{l} \eta\left[y_{ji,t} + \kappa\theta_{ji,t} + \kappa(1 - f_{ii,t})\theta_{ji,t}\right] \\ +\frac{1-\eta}{1-s_w}\left[e^{-\frac{c_{j,\tau}\tau_{n,i,t}}{\zeta_i}}c_{i,\tau}\tau_{n,i,t} + f(1 - e^{-\frac{c_{j,\tau}\tau_{n,i,t}}{\zeta_i}})\zeta_i + c_{h,j} + b\right] \end{array} \\
w^r_{ji,t} &= \eta\left[y_{ji,t} + \kappa\theta_{ii,t} + \kappa(1 - f_{ii,t})\theta_{ji,t}\right] + \frac{1-\eta}{1-s_w}\left[\zeta_i + b\right]
\end{aligned}$$

7.7 Model solutions

7.7.1 Choice between accepting On-site, Hybrid of Remote offer

Recall,

$$W^o_{n,jj,t}(\tau) - W^h_{n,jj,t}(\tau) = w^o_{n,jj,t}(\tau) - w^h_{n,jj,t}(\tau) - c_{j,\tau}\tau_{j,t} + e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}}c_{j,\tau}\tau_{n,j,t} + f(1 - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}})\zeta_j + c_{h,j}$$

$$W^r_{n,jj,t} - W^h_{n,jj,t}(\tau) = w^r_{jj,t} - w^h_{n,jj,t}(\tau) - \zeta_j + e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}}c_{j,\tau}\tau_{n,j,t} + f(1 - e^{-\frac{c_{j,\tau}\tau_{n,j,t}}{\zeta_j}})\zeta_j + c_{h,j}$$

With, $\tau^{R_1}_{j,t}$ is a solution of

$$(1 - s_w) \times \left(y^o_{jj} - y^h_{jj}\right) - c_{j,\tau}\tau^{R_1}_{j,t} + e^{-\frac{c_{j,\tau}\tau^{R_1}_{j,t}}{\zeta_j}}c_{j,\tau}\tau^{R_1}_{j,t} + f(1 - e^{-\frac{c_{j,\tau}\tau^{R_1}_{j,t}}{\zeta_j}})\zeta_j + c_{h,j} = 0 \quad (47)$$

and $\tau_{j,t}^{R_2}$ is a solution of

$$(1-s_w)\times\left(y_{jj}^{r}-y_{jj}^{h}\right)-\zeta_j+e^{-\frac{c_{j,\tau}\tau_{j,t}^{R_2}}{\zeta_j}}c_{j,\tau}\tau_{j,t}^{R_2}+f(1-e^{-\frac{c_{j,\tau}\tau_{j,t}^{R_2}}{\zeta_j}})\zeta_j+c_{h,j}=0 \tag{48}$$

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