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Locked in but logging on: Exploring the determinants that facilitated Taiwan's shift to remote work amid the global pandemic

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Abstract--This paper explores the factors influencing Taiwanese workers' decisions to engage in remote work during the COVID-19 pandemic, using empirical analysis based on the 2022 Digital Development Survey conducted by Taiwan's Ministry of Digital Affairs. The study finds that workers with higher education levels, those residing in digitally advanced regions, frequent users of computers or the internet, and those required to handle work-related messages after hours are more likely to either try remote work for the first time or increase their frequency of remote work. Additionally, younger workers are more inclined to engage in remote work for the first time, while female workers are more likely to increase their frequency of remote work. Using a Logit model, the study draws on work psychology, social psychology, and role expectation theory to deeply explore the impact of different individual characteristics on remote work decisions. The significant contribution of this study is its distinction between workers engaging in remote work for the first time and those increasing the frequency of remote work while also revealing companies' crisis management strategies during the pandemic, mainly how they selected workers with autonomy and digital skills to ensure business continuity. The findings provide an empirical basis for understanding the expansion of remote work during the pandemic and its potential to influence future work patterns, highlighting that the widespread adoption of remote work among certain groups of workers may offer valuable lessons for handling future emergencies.

Keywords---Initial remote work, intensified remote work, COVID-19 pandemic
JEL: J61, J62.

1. Introduction

The global pandemic of COVID-19 has led to unprecedented changes in working patterns. Although the pandemic began to spread widely in March 2020, according to data from the Ministry of Health and Welfare of Taiwan, the number of cases in Taiwan did not rise significantly until 2022. This virus spread mainly through interpersonal contacts, has not only caused a severe public health crisis but has also forced businesses and production to face enormous challenges, prompting many organizations to take remote action as their emergency response strategy (Nash & Churchill, 2020) and even make this change faster (Nagel, 2020; Spurk & Straub, 2020). However, existing literature has not sufficiently distinguished between "engaging in remote work for the first time" and "increasing the frequency of remote work." This distinction is crucial during the pandemic, as the challenges and decision-making factors faced by these two types of workers may differ significantly. However, more in-depth research is needed on this topic.

According to the Digital Development Survey of the Ministry of Digital Affairs in Taiwan, the number of workers engaged in remote work was only 11.2% in 2019 before the pandemic, which rose slightly to 15.2% in the year of the outbreak. But in 2022, as the pandemic in Taiwan warmed sharply, the proportion rose to 24.2%. The data demonstrates that, under the threat of COVID-19, remote work has shifted from emergency response to a core strategy for business operations.

However, empirical studies on the remote work behavior of Taiwanese workers during the pandemic still need to be made available, particularly in the Asia-Pacific region. Given Taiwan's proximity to mainland China and the close exchange of personnel and business between the two sides, the spread and impact of the pandemic were especially severe. Therefore, a systematic study of Taiwanese workers' remote work patterns during the later stages of the pandemic would be significant. Furthermore, while existing literature often focuses on the prevalence of remote work and its impact on entire industries, there needs to be more exploration at the individual level. For example, how individual characteristics such as age, gender, and education influence workers' decisions to engage in remote work has yet to be thoroughly analyzed. This study aims to explore these characteristics in-depth and analyze their impact on workers' choices regarding remote work.

For many workers, remote work saves travel time, provides flexible timetables, increases job satisfaction and efficiency, and increases loyalty and motivation in the company. It is a great benefit, especially for employees caring for their families. However, companies think only some employees are suitable for remote work. Therefore, companies should plan carefully, judge their needs, and select the right employees to meet business needs and maintain a work-life balance. Existing research needs to sufficiently explore the relationship between the level of digital development in a region and remote work decisions, even though this

plays a critical role in the feasibility of remote work. This study will further analyze how digital maturity in a region influences workers' choices regarding remote work.

Under the influence of the COVID-19 outbreak, remote work that had previously required detailed planning has now changed. Some organizations rushed to work remotely without a response plan (Diab-Bahman & Al-Enzi, 2020; Nash & Churchill, 2020) or under the compulsory requirement of a governmental decree (Matli, 2020). In the face of the pandemic threat, manufacturers who maintain operational activities, promote remote work, and consider employment safety also accept the model. Compared to the pre-pandemic state, the scale of remote work has increased, covering more industries and positions and driving upgrades in technologies such as video and collaborative software. This rapid change forced manufacturers to adjust their management strategies quickly. Previous literature has yet to explore the impact of different industries and job categories on adopting remote work. This study aims to fill this gap by analyzing how workers in the manufacturing and service industries and across various job levels adopted remote work during the pandemic.

For most workers, this is the "first time" such sudden and prolonged remote work has occurred (Matli, 2000; Moretti et al., 2020). While remote work is seen as good for balancing work and life, efficiency and mental health are threatened by a lack of preparation, sharing the same space with families, and because of the concerns and uncertainties of the pandemic. The lack of appropriate work facilities, such as professional communication tools and office equipment, exacerbates the work pressure and may negatively affect physical health.

Many employees experienced remote work for the first time during the pandemic, but some had already experienced it. Faced with the operational stress of epilepsy, manufacturers may prioritize those employees with the most experience, expanding their range of work and increasing the frequency of their long-term work. Since this group of employees does not require additional training, they can adapt quickly and maintain efficiency. During the global breakdown period, doing business is a top priority. Using experienced remote workers ensures business continuity and reduces business disruptions.

In summary, while remote work during COVID-19 has received significant attention, literature has not adequately differentiated between "first-time remote work" and "increased frequency of remote work." These groups likely faced distinct challenges and factors during the pandemic. Empirical studies on Taiwanese remote work behavior, especially in the Asia-Pacific, are scarce, focusing mainly on industry-level impacts rather than individual worker characteristics or regional digital development maturity. Moreover, the influence of industry and job level on remote work adoption still needs to be explored, highlighting the need to investigate Taiwanese workers' remote work behaviors further.

This study, based on remote work during the COVID-19 pandemic, uses data from the Digital Development Survey published by the Taiwan Ministry of Digital Affairs in 2022 to explore the factors determining the first usage of remote

employment of full-time workers in Taiwan during the epilepsy peak, as well as the increased frequency of long-term work among experienced people. The study focuses on the individual characteristics of workers, such as age, gender, education, and whether they live in areas with digital development and maturity.

This study on remote work during the COVID-19 pandemic differs from existing literature in three primary ways. First, this study categorizes workers as either first-time remote workers or experienced workers with an increased frequency of remote work. This categorization helps to understand manufacturers' response strategies to the pandemic and provides a deeper look at workers' working patterns, prompting companies to develop more accurate management strategies. Secondly, empirical analysis enables us to identify those employees who are the first to work remotely and those who are experienced but work more frequently, as well as to clarify the specific characteristics of workers assigned to different categories of distance work. Finally, although the outbreak of COVID-19 is a particular situation – the effects of which are always transient – similar emergencies will still occur. With this study, we can deepen our understanding of manufacturers' adaptation strategies in the face of emergencies and the perceptions and attitudes of remote workers.

Using data from a sample of 6,848 official workers surveyed and analyzed through the Logit model, this paper reveals that those workers with the highest educational levels, those living in more mature areas with digital development, those who frequently use computers or the Internet for work, often receive job messages after leaving work. The higher-ranking workers are more likely to work for the first time or to increase the frequency of their remote work. Young workers are more likely to engage in remote work for the first time, while women significantly influence the frequency of remote work. There are still differences in the adaptation of remote work in different industries, such as manufacturing and services. It is noteworthy that the characteristic factor effect of first-time remote work is stronger than the increase in the frequency of work, which indicates that when the number of infected persons increases sharply, manufacturers will give priority to the remote employee who meets the conditions for long-term work for the first time to ensure regular operation under the pandemic.

In addition to this section as an overview, the second section focuses on a review of the literature on remote work during the COVID-19 pandemic. The third section describes the source of the data. The fourth section defines the empirical method, the fifth section illustrates the analysis results, and the last section discusses the conclusion and extension.

2. Literature Review

Remote work is not a new work model, and Nilles (1975) refers to the decentralization of organizations caused by telecommunications technology that can lead to remote work. With the development of ICTs, remote work presents a diversified and continuously changing working environment (Matli, 2020), with increasing research in countries and industries. Barrero et al. (2023) explored the evolution of remote work from 1965 to 2023, focusing on the dramatic shifts triggered by the COVID-19 pandemic. Before the pandemic, only 7% of workers

engaged in remote work, but by 2023, this proportion had surged to 28%. Technology advancements such as video conferencing and cloud collaboration tools facilitated this shift.

The COVID-19 virus 2020 spread through human-to-human contact, making remote work rapidly shift from a plan to an essential action. Government-mandated interventions forced many businesses and workers, regardless of their preference for remote work, to pivot towards it (Molino et al., 2020; Como et al., 2021). This move ensured that workers could operate from home, avoiding infection (Manzo & Minello, 2020; Molino et al., 2020; Nash & Churchill, 2020; Prasad et al., 2020; Adisa et al., 2021; Como et al., 2021; Delfino & van der Kolk, 2021; Galanti et al., 2021). This paper will focus on consolidating the literature regarding emergency responses to the pandemic via remote work following the outbreak.

The feasibility of remote work varies by industry, geographic location, and technological integration during the COVID-19 pandemic. Dingel & Neiman (2020) found that 37% of U.S. jobs can be entirely performed from home, especially in metropolitan or affluent areas. For instance, the manufacturing sector has a relatively low proportion of remote-capable positions at just 22%. In comparison, educational professionals and technical services have notably higher proportions, at 83% and 80%, respectively. Gallacher & Hossain (2020) discovered that 41% of jobs can be done remotely in Canada. During the initial phases of the pandemic, those with limited remote capabilities were more likely to become unemployed. In Kuwait, Diab-Bahman & Al-Enzi (2020) highlighted that 60–70% of jobs can be executed remotely with appropriate ICTs and flexible hours, and this percentage could surge to 80–90% if a post-pandemic hybrid work model is adopted. In other words, replacing the functions in traditional office environments is impossible for complete remote operations, even under governmental mandates.

The ability to transition to remote work is unequal across different socioeconomic groups. Eslava et al. (2023), using Bogotá as an example, pointed out that low-income groups faced more significant risks during the pandemic because they lacked the conditions necessary for remote work. In other words, the presence or absence of remote work exacerbated existing inequalities during the pandemic. Sahut and Lissillour (2023) applied the extended Unified Theory of Acceptance and Use of Technology to analyze adopting remote work platforms. They found that behavioral intention and facilitating conditions significantly impacted the use of remote work, and they highlighted the moderating roles of gender and generational differences in adopting remote work. Fan and Moen (2023) discovered that hybrid work models positively impacted the subjective well-being of minority men and men with lower educational attainment. However, they may impose more pressure on white women, indicating that the effects of remote work vary based on factors such as gender and race.

Following the pandemic's onset, the advantages of remote work became more pronounced. Primary reasons include the reduction of commute time under lockdown measures (Manzo & Minello, 2020; Molino et al., 2020; Nash & Churchill, 2020; Prasad et al., 2020; Adisa et al., 2021; Como et al., 2021; Delfino & van der Kolk, 2021), offering flexibility in scheduling work and personal time

(Manzo & Minello, 2020; Nash & Churchill, 2020; Adisa et al., 2021; Como et al., 2021; Delfino & van der Kolk, 2021; George et al., 2022), experiencing lower job-related stress (Prasad et al., 2020), and balancing work with family care (Manzo & Minello, 2020; Molino et al., 2020; Nash & Churchill, 2020; Como et al., 2021; Delfino & van der Kolk, 2021). With the assistance of ICTs, there has been a noted increase in productivity (Manzo & Minello, 2020; Toscano & Zappalá, 2021; George et al., 2022) and job performance (Molino et al., 2020; Prasad et al., 2020; Como et al., 2021; Delfino & van der Kolk, 2021), consequently elevating satisfaction levels (Molino et al., 2020; Nash & Churchill, 2020; Prasad et al., 2020; Richter, 2020). Furthermore, remote work offered employers a way to sustain operations during the pandemic, ensuring business continuity (Manzo & Minello, 2020).

Regarding productivity, Kurdy et al. (2023) found that workload, job satisfaction, and work-life balance had significant positive effects on the productivity of remote workers, while job level did not significantly affect the relationship between these variables and productivity. Iannuzzi and Campolongo (2023) emphasized that remote work during the pandemic represented more of a shift in managerial control rather than a reduction of it. Morikawa (2023) pointed out that although the average productivity of remote workers is lower than that of office workers, it has improved over time due to the combined effects of learning and selection processes.

The impact of remote work on well-being has also garnered widespread attention. Brown and Leite (2023) found that strong social connections help reduce negative well-being, while a sense of organizational support can enhance work well-being and the remote work experience. However, employees with a stronger sense of organizational identification reported higher levels of negative well-being, possibly due to misalignment between employee and organizational expectations. Al Dilby and Farmanesh (2023) pointed out that virtual leadership can significantly enhance the job satisfaction of IT employees, mainly when leaders support work-life balance and build trust.

The pandemic accentuated the advantages of remote work, and its challenges and downsides also became apparent. Notably, the tug-of-war between work and family care became glaring for female workers (Nash & Churchill, 2020; Adisa et al., 2021; Fan & Moen, 2022). With the boundaries between work and home becoming blurred (Molino et al., 2020; Richter, 2020; Adisa et al., 2021; Como et al., 2021), home-based disturbances might interfere with work (Toscano & Zappalá, 2021; Fan & Moen, 2022). A household member's infection severely affects workers' working hours (Manzo & Minello, 2020). The lack of adequate home-based workspace and equipment might lead to health issues (Moretti et al., 2020), increased stress (Molino et al., 2020; Como et al., 2021; Delfino & van der Kolk, 2021; Galanti et al., 2021; George et al., 2022), elongated working hours, and overwhelming workloads (Fan & Moen, 2022; Molino et al., 2020; George et al., 2022). Additionally, due to the absence of direct communication with colleagues, feelings of isolation and psychological stress may arise (Moretti et al., 2020; Galanti et al., 2021; George et al., 2022).

Regarding autonomy and managerial control, Abgeller et al. (2024) pointed out that remote work increases employee autonomy but also leads to more excellent work intensity and blurred boundaries between work and life. Managers need to strike a balance between providing autonomy and maintaining control. Waldrep et al. (2024) found that dual-income households prefer hybrid work models, which helps them balance work and family life more flexibly, improving both satisfaction and productivity.

Although remote work is widely adopted in some industries and regions, its practical applicability varies with different circumstances. The pandemic makes the advantages of remote working more apparent, such as reducing travel and improving elasticity. Still, it also results in problems such as border blur, family interference, and difficulty communicating with colleagues. It is worth noting that remote employment has yet to replace traditional office work due to governmental blockade measures. Unlike the study of the early global outbreak in 2020, this paper plans to conduct an empirical analysis focusing on the peak of the Taiwanese pandemic in 2022, when the global pandemic ended and companies had accumulated two years of experience. In this context, we explore which specific labor movements may be more distantly distributed, providing a different perspective on the behavior of manufacturers.

3. Data

The evidence used in this paper is a sample of the 2022 Digital Development Survey (DDS) published by the Ministry of Digital Affairs (MODA) in May 2023. The DDS has been conducted annually since 2001, and each survey incorporates the latest information, communication, and Internet development issues of the year to grasp the digital life issues.

In the 2022 survey, the MODA included the impact of COVID-19 on Taiwan's digital lifestyle for the first time. Remote work was defined as "labor that can be conducted from a non-fixed workplace, handling business and tasks remotely." The survey asked respondents whether remote work was "a mode previously not used by the laborer but adopted due to the pandemic" and "was it a mode already in use by the laborer, but with increased frequency due to the pandemic?" The sudden onset of COVID-19, akin to a Black Swan incident, left many businesses unprepared. To maintain regular operations, firms had to adjust their workforce deployment, allowing some employees to remain at their original workplace while selecting others with specific characteristics to engage in remote work. Drawing on the DDS's survey content, this paper delves into the decision-making factors influencing laborers' initiation or intensified use of remote work during the COVID-19 pandemic.

The original survey received 15,142 responses, excluding students and part-time workers. Using the Taiwanese official definition of the "labor force" population aged 16-65, the final sample consisted of 6,848 full-time workers for the empirical analysis.

Table 1 presents the usage rate of remote work across various industries and job positions in Taiwan. Amid the pandemic, the service industry's adaptation rate of

14.23% surpassed that of the manufacturing sector at 12.32%. However, when observing workers who increased their frequency of remote work, the manufacturing sector's 8.01% was slightly higher than the service industry's 7.93%. Moreover, there was a significant discrepancy between groups within the service industry that had adopted remote work and those that still needed to. This suggests that while COVID-19 altered work modalities, industries exhibited varying adaptability.

Table1. Percentage of remote work during the COVID-19 pandemic

	Initial remote work			Intensified remote work		
	Yes	No	Difference	Yes	No	Difference
Industry						
Manufacturing industry	12.32%	12.67%	-0.35% ^a (-0.37) ^b	8.01%	7.05%	0.96% (1.31)
Service industry	14.23%	9.80%	4.43%*** (5.35)	7.93%	6.19%	1.73%*** (2.67)
Occupation						
Manufacturing industry						
Senior Officials & Managers	16.25%	11.77%	4.47%* (1.82)	18.22%	6.60%	11.62%*** (5.77)
Professionals	21.69%	10.11%	11.57%*** (5.70)	15.09%	6.35%	8.74%*** (5.20)
Technicians & Associate Professionals	17.39%	11.31%	6.07%*** (2.81)	5.79%	8.45%	-2.65% (-1.48)
Clerical Support Workers	6.40%	18.82%	-12.42%*** (-7.85)	3.77%	12.67%	-8.90%*** (-6.78)
Service industry						
Senior Officials & Managers	21.51%	13.44%	8.06%*** (4.51)	15.13%	7.14%	7.98%*** (5.78)
Professionals	23.78%	11.98%	11.79%*** (8.76)	13.53%	6.61%	6.92%*** (6.63)
Technicians & Associate Professionals	19.29%	13.63%	5.65%*** (3.27)	8.99%	7.80%	1.18% (0.88%)
Clerical Support Workers	9.19%	21.40%	-12.21%*** (-11.44)	4.75%	12.45%	-7.69%*** (-9.27)

a. Difference in mean values between remote & non-remote workers. b. t value; c. *** and * represent statistical significance at the 1% & 10%, respectively.

In the service industry, most tasks can be accomplished via telephones, computers, and the Internet. For instance, software development and data analysis can be conducted virtually anywhere. In contrast, the manufacturing sector requires specific locations and specialized equipment. This explains why, in the initial stages of the pandemic, the service sector, equipped with simple tools, found it easier to adapt to remote work. Manufacturing, on the other hand, necessitates comprehensive planning and management for remote tasks. As a result, manufacturing workers with prior remote work experience were likelier to be assigned remote tasks again during the pandemic. Not only did they have experience, but they may also have undergone company-specific technical

training, making them more inclined to increase the frequency of their remote work to ensure sustained performance.

Within the manufacturing and service sectors, the professionals exhibited the highest proportions of initial attempts at remote work during the early stages of the pandemic, accounting for 21.69% and 23.78%, respectively. They were followed by supervisors and managers, then by technicians, with clerical and foundational support staff showing the lowest percentages. Notably, across all job positions, the service sector reported higher proportions of remote work than the manufacturing sector. This could likely be attributed to professionals predominantly engaging in highly digitized tasks. With the assistance of information and communication technology, they are well-equipped to complete their primary responsibilities, making them more readily adaptable to the remote work paradigm.

Supervisors and managerial personnel, primarily responsible for planning and management, can conduct their operations via digital tools, such as video conferences, making transitioning to remote work relatively seamless during a pandemic. In contrast, the proportion of remote work among technical and foundational support staff was lower, mainly because their roles often necessitate operation at specific locations or with specialized equipment. Frontline staff, especially those involved in face-to-face customer service, faced more considerations when transitioning to remote work. This trend is also mirrored in the distribution of roles that increased their frequency of remote work, where higher-ranking positions exhibited higher proportions of remote work. Overall, the adaptation of remote work during the pandemic was intrinsically linked with job positions, the nature of tasks, and the requisite technological demands.

4. Model and Empirical Method

4.1 Model

According to role expectation theory, workers' job decisions are influenced by the differing role expectations from employers and families. The COVID-19 pandemic has altered these role expectations between work and family. Assuming that the utility of the i^{th} worker is affected by balancing work roles (R_w) and family roles (R_f) during the pandemic, the utility function U_i^{role} can be expressed as:

$$U_i^{\text{role}} = \alpha_i R_w^{\text{COVID19}_i} + \beta_i R_f^{\text{COVID19}_i} - C_i \quad (1)$$

Where $R_w^{\text{COVID19}_i}$ represents the work role expectations of workers affected by the pandemic, such as the increased demand for remote work. $R_f^{\text{COVID19}_i}$ refers to the family role expectations, such as the increased caregiving pressure during the pandemic. C_i represents the cost of trade-offs workers face between work and family roles, exacerbated by the additional stress brought on by the pandemic.

In work psychology theory, workers' job autonomy implies that remote work requires greater independence to manage their work schedules. During the

pandemic, workers' utility also stems from job autonomy ($A_i^{COVID19_i}$), as the overlap of work and family locations necessitates more flexible arrangements for handling tasks at appropriate times. In other words, workers need the autonomy to manage work and family responsibilities. Since remote work is conducted from home, it is also influenced by different factors such as workload and technical requirements (X_i). Therefore, the utility of workers under job autonomy can be expressed as:

$$U_i^{autonomy} = \gamma_1 A_i^{COVID19_i} + \gamma_2 X_i \quad (2)$$

Finally, according to social psychology, workers receive support from family, colleagues, and society during the pandemic, and these forms of support become crucial for workers' decisions to engage in remote work as the pandemic worsens. Therefore, the utility function of workers under social support can be defined as:

$$U_i^{support} = \delta_1 S_i^{COVID19_i} + \delta_2 Z_i \quad (3)$$

Where $S_i^{COVID19_i}$ represents the social support workers receive during the pandemic, such as the support provided by family members, which becomes particularly important due to close daily interactions. Z_i represents other control variables, such as workers' digital skills and social environment.

By synthesizing the three utility functions from role expectation theory, work psychology, and social psychology, the final utility function for workers can be derived, as shown below. It reflects how workers, during the pandemic, balance and make trade-offs among multiple role expectations, autonomy needs, and social support, leading them to engage in remote work from home. Therefore, the decision for workers to choose remote work depends on whether their utility exceeds a certain threshold U_0 . The conditions for choosing remote work can be expressed as:

$$\begin{aligned} U_i &= U_i^{role} + U_i^{autonomy} + U_i^{support} \\ &= (\alpha_i R_w^{COVID19_i} + \beta_i R_f^{COVID19_i} - C_i) + (\gamma_1 A_i^{COVID19_i} + \gamma_2 X_i) + (\delta_1 S_i^{COVID19_i} + \delta_2 Z_i) \end{aligned} \quad (4)$$

In workers' decision-making regarding their job choices, if U_i exceeds a certain threshold U_0 , the i^{th} worker will engage in remote work during the pandemic.

$$Remote_i = \begin{cases} 1 & \text{if } U_i > U_0 \\ 0 & \text{otherwise} \end{cases} \quad (5)$$

If the above equation is further transformed into a probabilistic form, the Logit model can be used to represent the probability of workers choosing remote work:

$$\Pr(Remote_i = 1) = \Lambda \left[(\alpha_i R_w^{COVID19_i} + \beta_i R_f^{COVID19_i} - C_i) + (\gamma_1 A_i^{COVID19_i} + \gamma_2 X_i) + (\delta_1 S_i^{COVID19_i} + \delta_2 Z_i) + \varepsilon_i \right] \quad (6)$$

Λ represents the cumulative distribution function, which describes the probability that various characteristic variables influence workers' decisions to choose remote work. ε_i represents the random error term, reflecting the influence of unobservable factors on workers' decisions.

4.2 Empirical Method

This study's empirical model is based on theoretical frameworks from work psychology, social psychology, and role expectation theory. Job autonomy and the Job Demands-Resources model are critical elements for understanding how workers respond to remote work arrangements in work psychology. Social psychology emphasizes the importance of social support and interpersonal relationships, especially during the pandemic, in the context of remote work. Role expectation theory further elucidates how workers' multiple roles in family and workplace settings influence their work mode choice. This paper integrates these three theoretical frameworks to explore the factors affecting workers' decisions to opt for remote work, and the empirical data is used to validate these factors.

In the DDS survey, this study formulated the decision of workers to engage in remote work during the pandemic as a binary variable, which can be represented as:

$$InitialRemote_i = \begin{cases} 1 & \text{if } first\ time\ remote\ work \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

$$IntensifiedRemote_i = \begin{cases} 1 & \text{if } intensified\ remote\ work \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

InitialRemote_i denotes workers who embarked on remote work for the first time during the pandemic. At the same time, *IntensifiedRemote_i* represents workers who had previous experience with remote work but increased their frequency due to the pandemic's impact. Since the onset of COVID-19 and the resulting societal restrictions were unforeseeable and uncontrollable for businesses, companies were constrained to consider how to maintain normal operations during the pandemic. The decision to allocate workers to in-person or remote tasks will likely be based on individual attributes, job nature, respective industry, and role. Hence, the remote working variables should be considered endogenous variables. Based on this, the regression model is established as follows:

$$\begin{aligned} Remote_i = & \alpha_0 + \alpha_1 Age_i + \alpha_2 Sex_i + \alpha_3 University_i + \alpha_4 Graduate_i + \alpha_5 DigitalArea_i \\ & + \alpha_6 iWorkRequest_i + \alpha_7 ICTWork_i + \alpha_8 notAIWork_i \\ & + \alpha_9 ManufacturingOfficials_i + \alpha_{10} ManufacturingProfessionals_i \\ & + \alpha_{11} ManufacturingTechnicians_i + \alpha_{12} ManufacturingClerical_i \\ & + \alpha_{13} ServiceOfficials_i + \alpha_{14} ServiceProfessionals_i \\ & + \alpha_{15} ServiceTechnicians_i + \alpha_{16} ServiceClerical_i + e_i \end{aligned} \quad (9)$$

Remote_i is the remote working variable assigned to the initial and intensified remote variables. The individual characteristics of the worker included in this paper include age (*Age_i*), sex (*Sex_i*), university (*University_i*), graduate (*Graduate_i*),

and the digital mature development area (*DigitalArea_i*) defined by the Taiwan Government.

In establishing the explanatory variables for Eq. (9), it is crucial to integrate perspectives from work psychology and role expectation theory. Role expectation theory, in particular, provides a deep and complex understanding of workers' decisions. From the work psychology viewpoint, job autonomy refers to workers' ability to control how they execute their tasks, including the scheduling of duties and the content of their work. This autonomy became especially significant during the pandemic, as remote work amplified the need for workers to manage their tasks independently. However, role expectation theory presents a more complex picture, where workers face internal demands for autonomy and external role expectations from various groups, such as colleagues, superiors, and family members.

These external role expectations can become ambiguous or conflicting, particularly in remote work settings. Younger workers, for instance, may feel more inclined to embrace remote work due to external expectations aligned with their digital skills and sense of autonomy. Conversely, older workers often face more significant role pressure when confronted with higher technical demands in remote work environments. While younger workers may thrive on the digital tools required for remote work, older workers' self-discipline and experience often allow them to perform more efficiently, mainly when remote work is associated with a certain level of seniority.

From a gendered perspective, role expectation theory reveals that women often experience more pronounced family-related role expectations, particularly during the pandemic. Their caregiving responsibilities and workplace demands necessitate a delicate balance between work and family roles. Consequently, women are more likely to opt for remote work to meet family and professional role expectations, significantly when these roles overlap or compete for attention.

The educational level also plays a crucial role in shaping workers' decisions about remote work. Highly educated workers, who typically possess greater job autonomy and hold critical organizational roles, often face higher role expectations from their colleagues and superiors. The pandemic intensified these expectations, as efficiency and self-discipline became paramount when nearly all workers transitioned to remote work. Role enrichment theory supports this view, suggesting that job satisfaction and performance improve when an individual's work role fulfills societal expectations. For highly educated workers, remote work offered an effective way to meet these expectations, leveraging their advanced problem-solving skills and familiarity with digital tools to navigate the uncertain and complex work environment during the crisis.

Geographic location further complicated the remote work dynamic during the pandemic, emerging as a critical factor in workers' decisions. From a social psychology perspective, workers residing in regions with advanced digital development were more likely to accept and adapt to remote work due to the favorable characteristics of their social environments. These areas benefit from more substantial internet infrastructure and a social climate that supports digital

work models, making workers more psychologically prepared to transition to remote work. The pandemic thus accelerated the shift to digital work environments, particularly in these regions, showcasing the resilience and resourcefulness of workers who could quickly adapt to new working methods.

Additionally, from the standpoint of work psychology, regions with advanced digital development provided workers with the technical support and resources necessary to respond effectively to remote work challenges. These technological resources helped mitigate potential barriers, instilling greater confidence in the workforce. Workers in these areas, already accustomed to frequent internet and technology use in their daily tasks, were better equipped to manage the increased job demands brought about by the pandemic compared to those in less digitally developed regions.

Role expectation theory can further explain the influence of geographic location on remote work opportunities. Employers in digitally advanced regions often had higher expectations of their workers, perceiving them as better suited to remote work demands. As a result, these workers were more frequently granted remote work opportunities during the pandemic and were expected to maintain high productivity levels. This expectation amplified the role of geographic location in shaping remote work decisions, as workers in these regions were more likely to be selected for remote work assignments or see an increase in the frequency of their remote work in response to the pandemic's challenges.

In the application of the second major category of work nature, this paper includes three variables: whether you will still receive work-related messages or be asked to process things on a job via the Internet after hours (*iWorkRequest_i*), the percentage of things that need to be done using a computer or a network in a job (*ICTWork_i*), and the recognition that the current work will not be replaced by automation or artificial intelligence in the future (*notAIWork_i*).

When workers are required to handle work-related messages after hours, this indicates a high job demand level from the organization, suggesting heightened role expectations. According to role expectation theory, continuous work demands may lead to role conflicts, particularly when family members expect workers to devote more time to caregiving. The clash between work and family roles becomes more intense, significantly increasing stress levels, especially when workers cannot meet both expectations. This tension was likely exacerbated during the severe phases of the pandemic. However, workers already accustomed to remote work, having adapted to asynchronous communication and independent work styles, were better equipped to handle these challenges. Their digital proficiency made them preferred candidates for remote work during the COVID-19 pandemic.

On the other hand, work that relies heavily on ICT technology, such as software development, data analysis, or digital marketing, can act as a valuable resource, helping workers manage the pressures arising from competing role expectations. According to role expectation theory, when job resources effectively support workers' ability to meet the demands of different roles, stress is reduced, and work performance improves. Consequently, ICT-dependent jobs allow for greater

flexibility in organizing work, helping workers balance professional and personal responsibilities at home, thus easing potential conflicts between work and family.

Furthermore, when workers believe their roles cannot be automated or replaced by artificial intelligence, it reflects a stable role expectation regarding the security of their professional skills. This sense of irreplaceability fosters greater job security and stability, making remote work more appealing as a secure option. Role expectation theory suggests that when workers clearly understand their role and future development within the organization, their engagement and job satisfaction increase. In contrast, jobs that are highly specialized or involve unique equipment or sensitive information and, therefore, cannot be easily automated may face more significant challenges in transitioning to remote work during the pandemic.

Ultimately, remote work is closely tied to the industry and position of the worker. This study differentiates between the manufacturing and service sectors. Job positions are categorized as executives, managers, professionals, technicians, and clerical support staff, leading to a cross-sectional formation of eight explanatory variables. According to role expectation theory, workers' role expectations vary by position, influencing their willingness to accept remote work. For example, supervisors and managers often have role expectations emphasizing autonomy and responsibility. As a result, they are more inclined to adapt to remote work, as their role expectations naturally align with the demands for self-management and task independence. This compatibility with high autonomy enables them to perform better in remote work environments.

On the other hand, frontline support staff in the manufacturing industry face unique challenges regarding remote work. Their role expectations are closely tied to operational tasks requiring physical presence. As a result, transitioning to remote work can lead to role conflicts, hindering their performance as they need help to effectively meet organizational and personal role expectations. This understanding of their challenges can evoke a sense of empathy in the audience.

The aforementioned elucidates the adaptation of three significant explanatory variables in this study, encompassing worker personal characteristics, the nature of the work, and industry and job position. In the empirical analysis, as the dependent variable is binary, this paper employs a Logit model to explore the impact of different role expectations on workers' likelihood of engaging in remote work during the COVID-19 pandemic. Additionally, the analysis provides insights into the probability of various types of workers being assigned remote work.

5. Results

Table 2 shows the experiment results using the Logit model, where the first number is the coefficient, the number in the middle summary is the marginal effect value, and the number of the small summary is the t value of the statistical significance. From the personal characteristics of the first column, younger workers are more likely to be assigned to remote work for the first time during the pandemic. Every decrease in age of 10 increases the likelihood of working remotely by 0.8%. The effect of age on the increased frequency of remote work is

still being determined. But gender is an essential factor. Women workers were 1.06 percent more likely to work remotely during the pandemic than men. This may be because, during the pandemic peak, family members in Taiwan were mostly locked up at home. This made women more inclined to use remote work to balance work and family care needs.

Table 2. Workers' remote work determinants during the COVID-19 pandemic

	Initial remote work	Intensified remote work
Age	-0.0058 ^{a*} [-0.0008] ^b (-1.92) ^c	0.0001 [0.00001] (0.05)
Sex	-0.0888 [-0.0135] (-1.29)	0.1527* [0.0106] (1.85)
University degree	0.8453*** [0.1282] (9.00)	1.1322*** [0.0799] (7.96)
Graduate degree	1.6125*** [0.3260] (13.54)	1.6273*** [0.1882] (10.05)
Digitally mature area	0.4876*** [0.0821] (5.93)	0.2724*** [0.0204] (2.88)
Receive online work requests after hours	1.4033*** [0.2092] (18.27)	0.6804*** [0.0468] (7.09)
Percentage of work requiring computers or the Internet	0.0155*** [0.0023] (14.96)	0.0146*** [0.0010] (10.56)
Job is entirely immune to AI replacement	0.0060 [0.0009] (0.08)	-0.1542* [-0.0103] (-1.64)
Manufacturing Industry-Senior Officials & Managers	0.9477*** [0.1834] (4.89)	0.2861 [0.0222] (1.13)
Manufacturing Industry-Professionals	0.5687*** [0.1006] (3.40)	0.4655** [0.0387] (2.20)
Manufacturing Industry-Technicians & Associate Professionals	0.3464* [0.0580] (1.89)	0.6543*** [0.0587] (2.87)
Manufacturing Industry-Clerical Support Workers	0.0043 [0.0006] (0.03)	0.0943 [0.0067] (0.44)
Service Industry-Senior Officials & Managers	0.6828*** [0.1234] (4.46)	0.5927*** [0.0514] (2.98)
Service Industry-Professionals	0.6418*** [0.1127]	0.5479*** [0.0455]

	Initial remote work	Intensified remote work
	(4.74)	(3.06)
Service Industry- Technicians & Associate Professionals	0.6236*** [0.1110] (4.11)	0.6398*** [0.0563] (3.22)
Service Industry- Clerical Support Workers	-0.0323 [-0.0049] (-0.26)	0.2268 [0.0161] (1.33)
Constant	-3.6681*** (-18.06)	-4.8146*** (-17.32)
Pseudo R ²	0.2721	0.1550
N	6848	

a. Coefficient; b. Marginal effect; c. t value; d. ***, ** and * represent statistical significance at the 1%, 5% & 10%, respectively.

Factors related to education attainment significantly impact the adaptation to remote work. Specifically, workers with postgraduate qualifications are more inclined to initiate or increase the frequency of remote work by 32.60% and 18.82%, respectively. This far exceeds the 12.82% and 7.99% for those with only a university degree, indicating that those with higher educational backgrounds are more predisposed to working remotely. Moreover, workers in regions with advanced digital infrastructure have an 8.21% higher probability of trying remote work for the first time. This could be attributed to the sudden onset of the COVID-19 pandemic, where a well-equipped hardware and software environment facilitated a swift transition from fixed workplaces to online setups, ensuring regular company operations. However, with the increase in the frequency of remote work, the marginal effect in these regions decreased to 2.04%. This may be because once workers had gained experience and the necessary tools for remote work, their geographic location became less pivotal.

During the pandemic, the nature of work influenced workers' inclination to try remote work for the first time. Workers who often received work messages after hours and those who needed a computer to complete their tasks saw their likelihood of remote work increase by 20.92% and 0.23%, respectively. However, when it came to intensifying the frequency of remote work, these figures dropped to 4.68% and 0.1%. On the other hand, workers who believed their jobs were difficult to replace by AI were less inclined to work remotely during the pandemic. This is likely because their roles required more physical interactions, specialized knowledge, sensitivity in operations, security considerations, or specific equipment. The pandemic emphasized the significance of their roles being less suited for a remote setting.

Regarding the industry and job position, as previously anticipated, individuals in higher-ranking positions are more inclined towards remote work, while ground-level employees tend to work from fixed locations. Especially among entry-level clerical support staff, there isn't a statistically significant difference in remote work tendencies. When transitioning to remote work, the likelihood of remote work for executives, managers, professionals, and technical staff in the manufacturing sector was 18.34%, 10.06%, and 5.8%, respectively. In contrast,

those figures for the service sector were 12.34%, 11.27%, and 11.1%. Although top executives in manufacturing had a higher probability of remote work compared to the service sector, middle-level professionals and technicians in the service sector showed a higher tendency than their counterparts in manufacturing. One possible explanation is that senior personnel in manufacturing are not directly involved in line operations. At the same time, mid-level workers in the services industry tend to have greater job flexibility than those in manufacturing.

When observing the industries and positions concerning the increased frequency of remote work, the propensity for executives and managers to work remotely remains positive, but it's no longer statistically significant. Due to the intense fluctuations of the COVID-19 outbreak in 2022, top executives may have needed to address unexpected issues on-site and swiftly adjust operational strategies. As a result, they might lean more towards working in the office. Additionally, their roles, which involve crucial decisions, may require face-to-face communication with their teams. Some managers might prefer directly supervising employees, especially in the manufacturing sector. Hence, even amidst a severe outbreak, they might still choose to work from the company premises rather than remotely. However, in the service industry, where there are no production line constraints, the probability of senior personnel increasing the frequency of remote work remains at 5.14%.

6. Discussions and Conclusions

6.1 Discussions

The importance of this study lies in its empirical contribution to guiding companies on how to make informed decisions regarding the implementation of remote work during large-scale crises. Specifically, remote work emerges as both a response to the pandemic and a strategic approach for quickly adapting to future challenges that may disrupt normal business operations.

The empirical findings of this research indicate that during the COVID-19 pandemic, the decision of Taiwanese workers to opt for remote work was influenced by multiple factors, which can be understood through the lenses of work psychology, social psychology, and role expectation theory. From the work psychology perspective, job autonomy is significant in determining workers' likelihood to choose remote work. Those with higher educational attainment (such as graduate degrees) and frequent use of computers or the Internet were more inclined to engage in remote work. This aligns with existing literature, highlighting that workers with greater autonomy are better equipped to adapt to remote work. Furthermore, individuals in higher-level positions, such as managers and professionals, tend to possess greater autonomy, making them more predisposed to remote work during the pandemic, as their roles typically require self-management and advanced skill sets.

From a social psychology standpoint, social support and interpersonal relationships were pivotal in shaping remote work decisions. Empirical evidence shows that female employees were more likely to increase the frequency of remote

work, likely due to the heightened challenge of balancing work and family responsibilities during the pandemic. In addition, workers residing in digitally advanced regions were more adept at adapting to remote work due to well-established social support networks and technological infrastructure. This confirms the critical role of digital infrastructure, such as reliable internet services and advanced ICTs, in promoting the transition to remote work. Companies can enhance their digital infrastructure to support remote work better.

Role expectation theory, a sociological concept, provides valuable insights into age-related differences in remote work adoption. The theory suggests that individuals behave in ways consistent with their social roles' expectations. The findings of this study align with this theory, suggesting that younger workers were more willing to try remote work for the first time. In contrast, those with prior remote work experience were more likely to increase their remote work frequency. This is consistent with the literature, which argues that younger employees have a higher tolerance for digital tools and can swiftly adjust to virtual work environments. Conversely, more experienced workers demonstrated greater effectiveness in remote work during the pandemic, drawing on their self-discipline and efficiency.

An essential contribution of this study lies in its exploration of how companies selected remote workers during the pandemic. Unlike prior studies, which predominantly examined the effects of remote work on job performance, employee satisfaction, and work-life balance, the promotion of remote work during the COVID-19 crisis was driven more by the urgency of ensuring business continuity. Consequently, companies prioritized employees capable of maintaining productivity from home over those who preferred or were suitable for remote work.

Moreover, this article emphasizes the essential role of ICTs and Internet services in facilitating remote work. Regardless of the nature of the work, remote work would have been considerably more challenging to implement without robust and reliable communication technologies. During the pandemic, companies with pre-existing technological infrastructure found it easier to transition to remote work.

Finally, although the pandemic accelerated the adoption of remote work, many companies may still perceive it as a temporary measure rather than a long-term operational strategy. As the pandemic subsides, some organizations might revert to traditional work models. However, the widespread adoption of remote work during this period, coupled with the accumulated experience, will likely have a lasting and profound impact on the future evolution of work models. Remote work may become a more permanent feature of the work landscape, with companies adopting hybrid models that combine remote and in-person work.

6.2 Conclusions

This study employs a Logit model to analyze a national-level sample from the Digital Development Survey, which the Taiwanese government collected during the COVID-19 pandemic. The study explores the factors that influenced the

emergence of remote work under pandemic restrictions. Unlike previous academic research, this paper explicitly distinguishes between two scenarios: workers engaging in remote work for the first time and workers increasing the frequency of remote work during the pandemic. Given the sudden onset of COVID-19 and the resulting challenges for businesses in planning, this study seeks to analyze how companies arranged remote work at the height of the pandemic to gain a deeper understanding of their crisis management strategies.

The empirical results indicate that several common factors influenced first-time engagement in remote work and the increased frequency of remote work during the pandemic. These factors include higher education levels, residence in regions with advanced digital infrastructure, blurred boundaries between work and personal time, frequent use of computers or the Internet for task completion, and higher-level positions. Additionally, the results reveal that younger workers were more likely to engage in remote work for the first time, while female workers were more inclined to increase their frequency of remote work.

The findings further suggest that the decision to engage in remote work was shaped by individual factors and the company's emergency response strategies during the pandemic. Companies were more likely to select employees with high job autonomy and strong digital skills for remote work during this period, as these employees were better equipped to manage their tasks efficiently and adapt to digital environments. This is consistent with the theory of job autonomy found in the literature, which indicates that when selecting employees for remote work, companies prioritize those who are well-suited to work from home and can maintain high levels of efficiency in emergencies.

Moreover, the empirical results show that geographic location and the maturity of digital development significantly impacted the choice to engage in remote work. Workers residing in regions with more advanced digital infrastructure were likelier to try remote work for the first time. However, as workers accumulated more experience with remote work, the importance of geographic location gradually diminished. This finding aligns with the literature on long-term adaptation effects, which suggests that digital infrastructure plays a more critical role in the early stages of remote work adoption.

When comparing the factors influencing first-time remote work adoption to those affecting the increased frequency of remote work, the effect sizes for first-time adoption were generally more significant. In the context of a sudden and severe pandemic, companies were more likely to require employees with remote work capabilities to adopt this model to ensure business continuity. Additionally, workers with prior remote work experience were more likely to be given additional remote work opportunities, as their previous experience likely enhanced their efficiency in this work mode.

Finally, although the pandemic has accelerated the adoption of remote work, many companies may still view it as a short-term emergency measure rather than a long-term operational strategy. As the pandemic subsides, these companies may return to their traditional work models. Nevertheless, the widespread adoption of remote work during this period, coupled with the accumulated experience, will

undoubtedly have a profound and lasting impact on the transformation of future work models.

Statements and Declarations

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