Will Teleworking Software Benefit from Covid-19 Pandemic: A Long-term Perspective

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Abstract. Since the beginning of the epidemic brought about by the new coronavirus in early 2020, people's lives and various industries around the world have received varying degrees of impact and has continued to this day. it is the Chinese market, the U.S. market or the European market, after the rapid spread of the new epidemic in the short term, investors panic, the tendency of capital risk aversion led to a large number of capital "flight" from the financial market, and thus the financial market indices fell off a cliff, but after the beginning of the epidemic online office industry also appeared in the short term However, the online office industry also experienced a great deal of positive sentiment in the short term after the epidemic began, and the market reacted to this information. VAR and ARMA-GARCH models were used to examine the impact of the pandemic outbreak on telecommuting industry returns and volatility, respectively. And we get a result that the Covid-19 affect the whole financial market more dramatically in other countries, but affect online office industry more obviously in China.

Keywords: VAR; ARMA-GARCH models; Telecommuting; Covid-19.

1. Introduction

1.1. Background

The impact of the new epidemic has changed the way people live and work, as more people are choosing to work online due to travel restrictions. Telecommuting work arrangements have been implemented in several countries, providing employees with work flexibility, and improving the work experience. It offers their employees flexibility at work and improves the work experience [1]. Telecommuting was not a post-epidemic product in the 1970s when people used telephone lines as a network bridge to connect hosts located in satellite offices and business districts via non-intelligent terminals. It was only stimulated by the epidemic that its advantages became more evident when people's travel was considerably restricted, combined with the ubiquity and convenience of computers. Because telecommuting does not need to be bound by space and geographic location can be real-time, compared with the traditional office its advantages are clearly reflected, especially in this time of travel received a large degree of restriction. At the same time, the challenges are also obvious. First, in the telecommuting mode, people lack the invisible constraints and supervision in a fixed office environment, and there is less competition from colleagues visible to the naked eye, so staff self-discipline and teamwork may be reduced; second, the process of evaluation will become difficult, and performance appraisal will be more results-oriented, which will make everyone very painful, compared to pure telecommuting, "remote + centralized office "Third, the interaction between colleagues will be reduced, the stickiness of the organization will be reduced, and the relationship between colleagues may become online, and the management of employee groups will become project-based management or even outsourcing management based on online work groups, eventually forming a self-organizational management model [2].

The rest of the paper is organized as follows. The second part is a literature review that includes an analysis of the impact of the new crown epidemic on telecommuting and how the epidemic brought about these impacts, and concludes with a summary of the literature review. Then comes the third part, where the ARMA-GARCH model is set up and presented using the relevant data obtained. In the fourth part, the model given in the third part is subjected to VAR sizing as well as ARMA sizing and the results are estimated by ARMA-GARCHX. Finally, conclusions are drawn and predictions are made to give feasible and innovative suggestions for the future development of the telecommuting industry in the normalized epidemic.

1.2. Literature review

In a study released in June, researchers at the Becker Friedman Institute at the University of Chicago studied nearly 1,000 jobs by questionnaire and found that while there are significant differences between cities and industries, 37 percent of jobs in the country can be done entirely from home and pay for such jobs is 46 percent of total wages in the United States. The study also looked at an additional 85 jobs. The study also looked at 85 additional countries and regions and found that low-income economies were able to offer fewer home-based jobs, with half as many home-based jobs in markets where GDP per capita was less than one-third of that in the U.S., suggesting that more telecommuting opportunities are available in developed economies [3]. From the employer's perspective, ensuring that employees are able to work from home at or above their normal commute to work is an inevitable consideration when deciding whether to telecommute [4]. From the employees' point of view, due to the impact of the new epidemic, the team is aware of and accepts the telecommuting status, but in the actual operation of the team, the number of tasks to be completed is heavy, and the motivation of the team members has decreased compared to the first phase of telecommuting [5]. It should be noted that although telecommuting can meet most of the needs of work collaboration during the epidemic, it mainly targets knowledge workers who use computers to work, and for industries that rely heavily on offline scenarios, such as manufacturing, logistics, and retail, telecommuting can only partially solve the problem at best [6].

Eventually found a relationship between the online office and Covid-19. The online office industry has seen a sharp rise in the short term, but also a sharp decline, which is very different from other industries. In addition, in other countries Covid-19 has had a more significant impact on the overall financial market, but in China the impact on the online office industry has been more pronounced. To sum up, the COVID-19 epidemic has brought business opportunities to online office, but it is overly dependent on the COVID-19 epidemic. As we have studied, the COVID-19 epidemic has had a great impact on the financial markets of various countries, and the online office industry has risen. Although the online office industry has rapidly warmed up in a short time, the good times are not long, followed by a sharp decline in the industry market. This is both an opportunity and a challenge for the financial market. It can be seen from this that we still need to constantly tap its potential, popularize online office, extend its life cycle, and make its value no longer dependent on COVID-19. At the same time, the impact of online office in the overseas market is also different from that in the Chinese market. Due to the different epidemic prevention and control, its influence in China is more significant.

2. Vector-autoregression

2.1. Data source

This paper uses the the stock index which comes from the choice financial terminal [6], the figure of China's Covid-19 is from the National Health Commission of People’s Republic of China [7], and the figures of overseas Covid-19 are from WHO [8]. Additionally, all other data are calculated by researchers by Stata.

2.2. ADF test

Before building VAR model, stationarity in time series should be considered. Stationarity does not mean that the data will never change all the time, but indicates that the tracks or the ways it changes doesn't depend on time. The stationarity analysis is essentials because if series cannot match this condition, the following research may be meaningless due to the models is difficult to predict the future changes.

Therefore, the first step is to analyse the ADF test. Statistically, augmented Dickey–Fuller test (ADF) is used to test the time series which null hypothesis is only existing a unit root in this model, and as needed, the alternative hypothesis is the model is stationarity.

Table 1. ADF test.

Variables	t-statistic	p-value
Online office		
Index	-1.817	0.6965
Yield	-17.373	0.0000***
New confirmed cases		
China	-4.708	0.0007***
Overseas	-7.539	0.0000***

According to observe the ADF test, the series can be saw as stable if p-value is small enough and signed for "*". Normally, the outcome of t-statistics would be a negative number. Smaller t-statistics which ADF test get, smaller p-value became, in other words, the test is more tend to against the null hypothesis. As Table 1 indicates, the p-value of online office yield and new confirmed cases in China or oversee are 0, 0.0007 and 0, which are less than 0.1, so those series should be seen as stationarity statistically.

2.3. VAR model identification

After testing the stationarity of series, VAR model can be established to predict the rate of return for online office during the Covid-19. The formula of VAR model is shown below:

$$X_t = \sum_{t=1}^{p} \prod_t X_{t-i} + U_t \tag{1}$$

There are two points need to be confirmed to build the VAR model. Firstly, the endogenous and exogenous variables should be Determined. In this research, the variables are the rate of return for online office, new confirmed cases in China and new confirmed cases oversea. Then the second point is to find the maximum lag order of VAR model. The lag variables are used to explain the endogenous variables (k) with mutual influence. If k is too small, the autocorrelation problem of errors may lead to the excessive error of the model parameter estimation. Contrarily if k is too large, the degree of freedom of the model will reduce, which directly affects the effectiveness of the parameter estimation of the model. Therefore, finding a suitable k is an important part in building VAR model. There are lots of different way to determine this number. For instance, LR likelihood is a useful method. When LR are greater than the critical value, it is considered that the lag order of VAR model is not high enough, and more lag variables need to be added as explanatory variables until LR is less than the critical value. However, if sample size is not large enough compared with the number of estimated parameters, there will be a large difference between the limited sample distribution of LR and the asymptotic distribution of LR. AIC is another method to determine the lag orders. The formula of AIC is shown below:

$$AIC = log[\frac{\sum_{t=1}^{t} e_t^2}{T}] + \frac{2k}{T} \tag{2}$$

$$\min\{AIC\} = \log[\frac{\sum_{t=1}^{t} e_{kt}^2}{\sum_{t=1}^{t} e_{(k+1)t}^2}] - \frac{2}{T}, \quad (3)$$

From the formula, it is found that if there are VAR models with lag orders of K and K + 1, the closer their AIC are, the more appropriate the lag order is. In this research, AIC is chosen to determine the lag order. Hence after putting the data into Stata and performing the table 2, 7 is the best choice to be the lag orders.

Table 2. VAR model identification.

Lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	-388.059				0.0008	1.4483	1.4576	1.4722
1	197.061	1170.200	9	0.000	0.0001	-0.6854	-0.6481	-0.5900
2	283.436	172.750	9	0.000	0.0000	-0.9719	-0.9067	-0.8050
3	316.391	65.909	9	0.000	0.0000	-1.0607	-0.9674*	-0.8222*
4	332.374	31.966	9	0.000	0.0000	-1.0865	-0.9652	-0.7766
5	348.122	31.497	9	0.000	0.0000	-1.1115	-0.9623	-0.7300
6	357.085	17.926	9	0.036	0.0000	-1.1114	-0.9342	-0.6584
7	370.690	27.21*	9	0.001	0.0000*	-1.1284*	-0.9233	-0.6039
8	374.508	7.6365	9	0.571	0.0000	-1.1092	-0.8761	-0.5132
9	381.349	13.681	9	0.134	0.0000	-1.1012	-0.8402	-0.4337
10	389.212	15.726	9	0.073	0.0000	-1.0970	-0.8080	-0.3579
11	393.988	9.5525	9	0.388	0.0000	-1.0814	-0.7644	-0.2708
12	398.823	9.6707	9	0.378	0.0000	-1.0660	-0.7210	-0.1838

2.4. VAR stability

To verify whether the above VAR model is stationary or not, the roots of the companion matrix should be plotted by Stata. The VAR model can be considered as a stationary model if and only if all eigenvalues of the coefficient matrix fall in the unit circle. According to figure 1 shows, this model matches the condition so that the stability is proved.

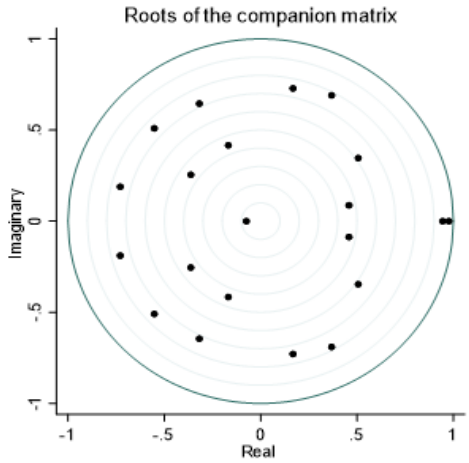

Figure 1. VAR stability.

2.5. Impulse response & Cumulative response

Fundamentally, the COVID-19 outbreak in early 2020 caused turbulence in the global financial market. In the short term after the rapid spread of the COVID-19 epidemic in China, the United States and Europe, investors were in panic. The risk aversion tendency of funds led to a large number of capitals "fleeing" to the financial market, and then the indexes of the financial market fell rapidly. The source form OECD indicates that as a result of the COVID-19 outbreak, the global trade may decrease by 12% to 32% and FDI flow is predicted to decline by around 40% in 2020. Additionally,

equity markets suffered from sell off at begin of COVID-19 outbreak, most of financial condition also tend to be constrictive [9]. Then those cases also influenced global capital flows as vicious spiral.

However, there are still a few industries which even became better than before, including medicine, games, and live broadcast. After the outbreak of the Covid-19, the online office also had a positive environment in a short time, and the market also reflected this situation. The short-term online office industry rises sharply, but it also has a sharp decline after that. It can be seen as a very normal market wave because of the overreaction of many investors. In the long run, with the deepening of people's understanding of COVID-19, whether behavior will return to rationality and whether this effect keeping need to be tested empirically.

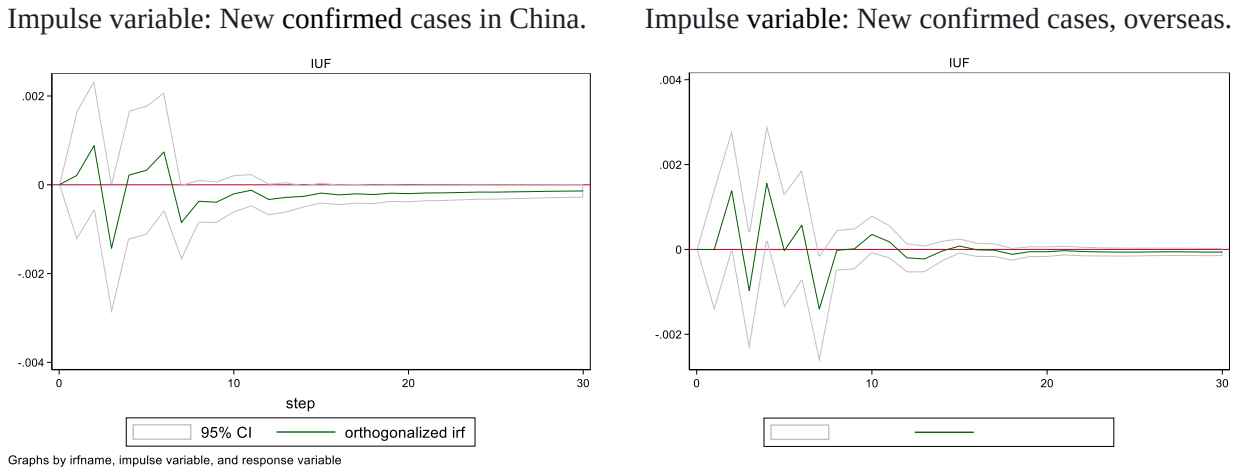

Figure 2. Impulse and response.

From the estimated results of impulse response (Figure 2), whether it is the number of newly diagnosed cases in China or overseas, the impact of one unit during the period of T = 0 will always cause the online office industry to experience a volatile market in the future, with an amplitude of slightly less than 0.2%. Accordingly, it is difficult to judge the net impact of the normalization epidemic on the online office industry's return rate only based on the impulse response function. Therefore, the cumulative response should be discussed as further research.

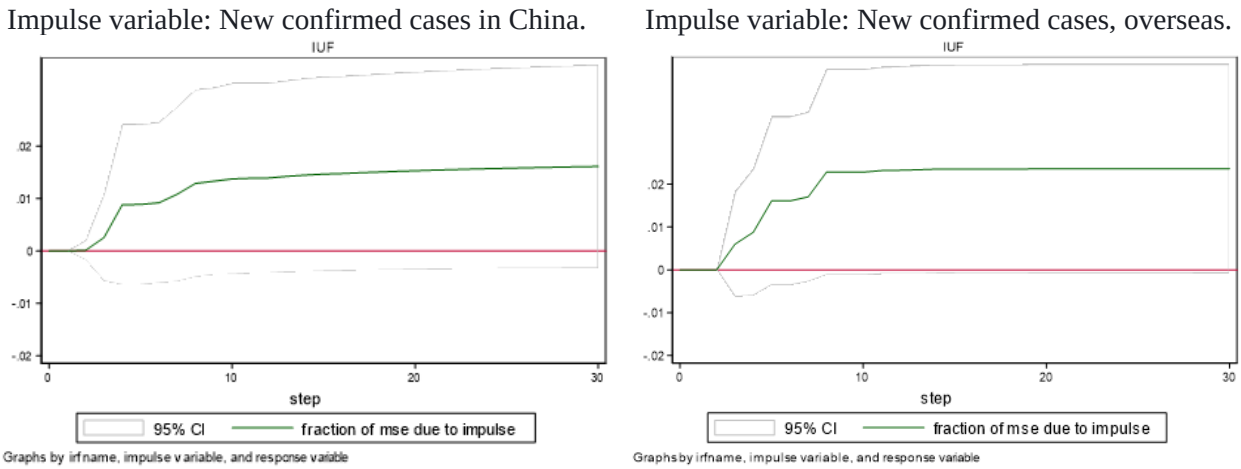

Figure 3. Cumulative response.

Figure 3 uses the cumulative response function to examine the cumulative impact of the current Covid-19 impact on the online office industry in the future. It is easy to find that the new confirmed cases in China increased by 1% in the period of T = 0, and the impact on the return rate of the online office industry in the next 30 periods is about 1.5%. Similarly, the cumulative effect of overseas shocks is slightly more than 2%. Maybe the reason why the cumulative impact of overseas shocks is greater than that of China is the number of overseas confirmed cases is larger and the outbreak period is also longer.

3. ARMA-GARCH

3.1. ARMA Order Identification

In this section of the article, the PCAF and ACF methods are used to observe the degree of auto-correlation and partial auto-correlation of the return data, which are helpful to provide a reliable reference for the number of necessary orders for subsequent data modeling.

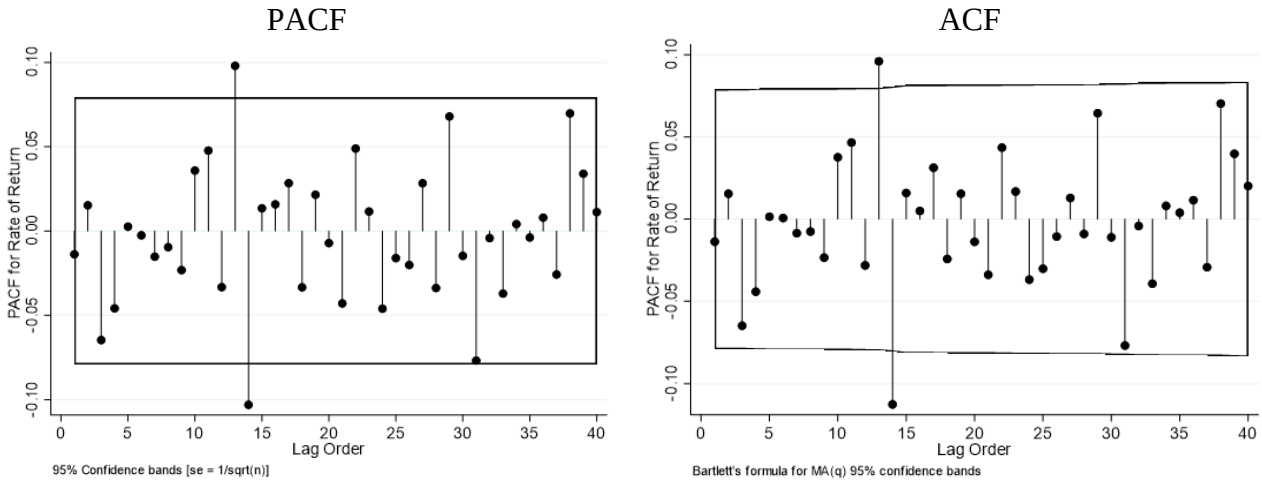

Figure 4. PACF and ACF.

As shown in the figure 4, the autocorrelation and partial autocorrelation tests are observed from 1 to 40. From the results of the above data, at order 13 and 14, the data is beyond the confidence interval and beyond the confidence interval, so this paper chose the lag period for subsequent empirical testing. Therefore, the two unknowns of AR (p) and MA (q) are both 12.

3.2. ARMA-GARCH

In order to forecast the variance of future online industry returns, the ARCH model is next used to observe the characteristics of online industry return vitality. And the consequences are shown in Figure 5.

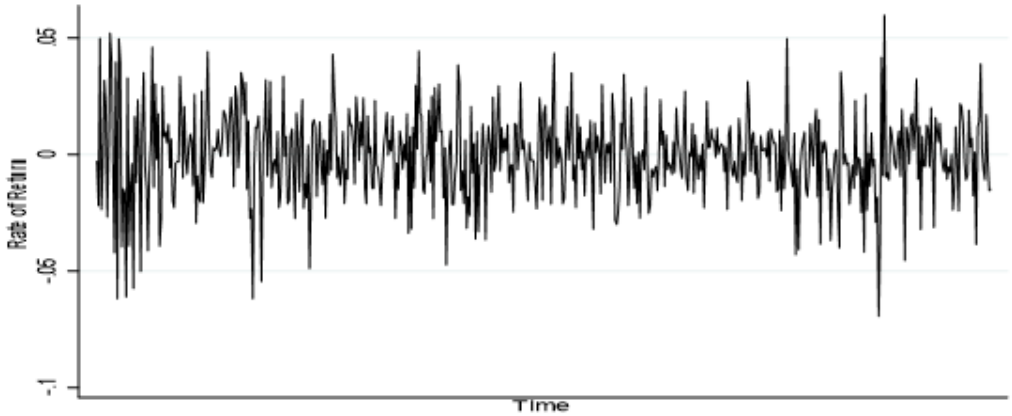

Figure 5. Yield.

From figure 5 return value time series data in the early volatility is significantly higher than the late volatility, and the middle period data tends to be relatively flat. Especially in the late period, the data is obviously volatility less than other periods, but after that the return volatility, the size of the return period distribution is loose. So, it can be concluded that the industry stock data aggregation phenomenon.

Based on this phenomenon, then this paper observed the characteristics of the data, and the order has been confirmed by the corresponding methods. It still needs further empirical tests on the return fluctuations of the industry to ensure the objectivity of the obtained conclusions.

Table 3. ARMA-GARCHX estimation results.

Variables	(1)			(2)		
	Coefficient	Std. err	p>|Z|	Coefficient	Std. err	p>|Z|
Mean equation						
AR, L13	-0.2971	0.4011	0.459	-0.4654	0.3891	0.232
MA, L13	0.3810	0.3884	0.327	0.5348	0.3708	0.149
Constant	-0.0003	0.0007	-0.633	-0.0001	0.0007	0.887
Variance equation						
New confirmed cases						
China				0.2466	0.0940	0.009
Overseas	-0.2038	0.0537	0.000			
GARCH (1, 1)						
ARCH, L1	0.0449	0.0198	0.024	0.0567	0.0200	0.005
GARCH, L1	0.8748	0.0581	0.000	0.9076	0.0305	0.000
Constant	-8.0023	0.6124	0.000	-12.3361	0.7828	0.000

Because the sequences have an autocorrelation, an autoregression sliding average model (Autoregressive moving average model) is established. The ARMA (p, q) model formula is shown below:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \ldots + \epsilon_t + \alpha_1 \epsilon_{t-1} + \ldots + \alpha_k \epsilon_{t-k} \tag{4}$$

The regression results of ARMA (1, 1) in China and ARMA (1, 1) abroad were obtained by fitting the ARMA model to the ARMA (1, 1) model. Meanwhile, the GARCH model is used to model the variance of the error. The GARCH model fitting equation is:

$$\begin{cases} V_t = \sqrt{h}\varepsilon_t \\ h_t = W + \sum_{i=1}^{p} \gamma_i h_{t-i} + \sum_{i=1}^{p} \gamma_i h_{t-i}^2 \end{cases} \tag{5}$$

The model adds to consider the autocorrelation of the heteroscedastic function according to the ARCH, effectively fitting the heteroscedasticity function with long-term memory, and thus it is significantly more accurate to fit the data about the heteroscedastic types.

Judging from the results in Table 3, the P values of AR. L13 and MA. L13 are insignificant. The significant P-value in model 2 is also much higher than 0.1. After the mean equation controls for the autocorrelation, the coefficients of ARCH (1, 1) and GARCH (1, 1) were significantly positive. This shows that there is an obvious conditional heteroscedastic difference in the online office industry fluctuation ratio, so GARCH modeling can be carried out.

The above analysis just proves the empirical applicability of the GARCH model, improving the model fitting accuracy on the basis of conditional heteroscedastic differences. However, to improve the accuracy of parameter estimation, it is still necessary to establish the GARCH (1, 1) model to verify that the regression results. As shown in table 3, the number of confirmed cases of the epidemic in China increased by 1%, while the volatility of the domestic online office industry increased by 0.2466, and it is significant at the P value of 0. 01.. Similarly, the number of overseas COVID-19 cases increased by 1%, while online office industry volatility fell by 0.2038, the overseas online office market returns are obviously and domestic different trend, negative correlation. This phenomenon may be due to the lack of overseas government control. Since 2019, the outbreak of COV-19 leads to a decline in the healthy workforce overseas compared to China. Overseas companies did not take online office to solve the problem, which makes the sick staff at home unable to take online work to complete their tasks, so there is a negative significant relationship.

Finally, according to the results of the lag period regression in table 3, overseas and Chinese regression error is significant P value 0.01 level first order positive correlation, which said the lag period for the current has obvious positive effect. So, take GARCH for empirical verification is in line with the characteristics of the data itself. The reason for this is that the better earnings performance of returns is expected to be better next time, and the opposite is expected to be lower next time, thus increasing the volatility of the industry data. Moreover, the arguments are recursed step by step according to the logic of the model itself, and the results of the data finally pass the significance test, so the test is objective and reliable.

4. Discussion

According to the series analysis by Stata, this paper finds that Covid-19 certainly affect the financial market in both China and oversea. From the turbulence in global financial markets, people's lives and various industries are influenced by Covid-19, as introduction indicates, can also be deduced. As this paper shows, the online office is one of the few industries which did not get the negative effect or even be benefit from it. It is supposed that one of the reasons is many local governments encourage or order people to work online, which maybe is also the reason why the number of new confirmed cases in China increase will cause the increasing of volatility of online office industry return but does not happen overseas. As the Becker Friedman Institute at the University of Chicago shows, which referred in introduction, there are many jobs can be finished online. Governments may find the relative between Covid-19 and online office more clearly, so maybe to support develop of online office is a good way for them to relieve relevant employment pressure. However, as introduction part demonstrates, for the employees, the number of tasks is still hard to complete online. In addition, many industries are even impossible to work online. Therefore, maybe to explore the hybrid work in balance instead of working just online or just in office is an important topic not only for governments, but also for all the companies. Research of McKinsey [10] also observe this tendency, as Figure 6 shows, more employees are likely preferring to work by hybrid working way comparing with fully on-site. For investors, this paper suggests that if they are willing to invest online office industry, maybe the need to observe the tendency of Covid-19 and its relevant policies more frequently. Besides that, it is better to invest the online office companies in China instead of overseas because investors can predict them easier by observing Covid-19.

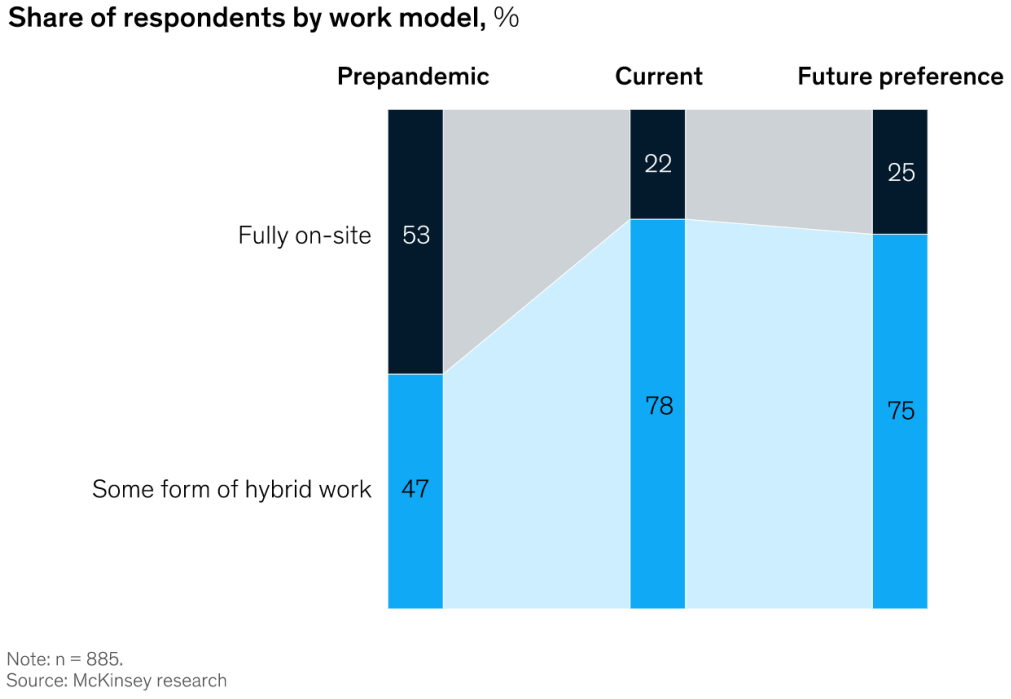

Figure 6. Working Way Preference.

5. Conclusion

Above all, in this essay, the researchers trying to find the relationship between online office and Covid-19. From the output of Stata, it is considered that the financial market index fell precipitously due to the Covid-19. However, distinct from other mostly industries, the short-term online office industry has seen a sharp rise, but it has also seen a sharp decline one later. Furthermore, the situation in China also has some differences compared with other countries. For whole financial market, the cumulative impact of overseas shocks is greater than that of China's shocks, which may be caused by the large number of overseas confirmed cases. And for online office industry, flowing the increasing of the number of new confirmed cases in China, the variance of online office industry income will also rise, but the increase in the number of overseas confirmed cases has no similar effect. In conclusion, the Covid-19 affect the whole financial market more dramatically in other countries but affect online office industry more obviously in China.

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