The Impact of Technology and Other Working Relevant Factors on Worker's Performance during the Covid-19 Pandemic in Indonesia

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***Abstract*— This study examines the impact of internet-based technology and other working relevant factors on workers' performance during Covid-19 pandemic in Indonesia. The result shows that internet-based technology use significantly and consistently contributes to workers' performance. Other factors that determine workers` performance are motivation and education, while commitment, stress, age, and gender do not show a significant impact on a worker's performance. These results have a policy implication by which companies or organizations and the Government should concern about developing workers' skills and providing appropriate working facilities to support the internet-based technology use, especially outside Java Island without differentiating workers' gender and age.**

Keywords— worker's performance; work from home policy; covid-19 pandemic; technology.

I. INTRODUCTION

Most countries including Indonesia have attempted to minimize the spread of Covid-19 by applying social interaction-based distancing policies. One of the policies is work mode from home or commonly known as work from home (WFH) which is an alternative mode of working when job activities are mostly or fully conducted at home. WFH is characterized by using tools with internet technology on working activities such as telecommunicating, virtual, cloud, etc., that make a physical presence at work become less necessary [1]. Such characteristics are in line with the characteristics of Industry 4.0 such as cooperating and coordinating technologies, and self-decision-making systems [2].

There are some advantages when applying to WFH. This mode of work raises issues of workers' performance and life balance and profitability. Bloom and Van Reenen [3] argued that by implementing the WFH mode, organizations/companies benefit from the efficiency of maintaining office buildings such as electricity, air conditioning or building rental, etc. Krasulja, Blagojevic, and Radojevic [4] stated that the balance between work and personal life was achieved through the WFH mode. The WFH mode allows workers to express their creativity better because the environment and office work schemes stress them out and affect their productivity [4].

Covid-19 pandemic speeds up the need to adapt to disruptive change and advanced technology [5], which can be applied when applying WFH. The term "New Normal" is interpreted as a post-pandemic situation in which new equilibrium arises due to major disruptions triggered by the Covid-19 pandemic [6]. In this situation, firms need to adapt their strategic management with technological, socio-political, and institutional changes to sustain their business [7].

Adaptive capacities are needed in an innovative technology environment especially related to digital technology to support the process of decision making and to cover many participants [5]. Such capacities are associated with the ability to utilize the industry 4.0 related technology focusing on intelligence, products, information, and communication networks such as big data, cloud computing, and open-source software [2].

In mid-March 2020, the Large-Scale Social Restrictions policy was implemented and required some Indonesian workers to work from home. Such implementation affected the performance of workers in all sectors as the infrastructure and environment of working activities during WFH are different from those of working from the office (WFO). Investigating the determinant factors of workers' performance during WFH due to the Covid-19 pandemic becomes necessary for policymakers including a firm's manager who are struggling to adapt to a new working environment such as new regulations, new adjustment strategies for a living, new perceptions of occupations, and modern technology.

However, the literature indicates the lack of investigations of the determinant factors of workers' performance during the implementation of WFH policy in the Covid-19 pandemic

period. This study fills the gap of previous studies by investigating the main determinant factors of workers' performance when WFH policy is implemented in the period of Covid-19 pandemic in Indonesia

II. WFH and Workers' Performance Determinant Factors

Remote working is labelled in many ways. One of them is working from home (WFH) which means workers do job activities with non-traditional working practices using information and communication technologies (ICT) such as telecom-muting, virtual, or cloud [1],[8],[9]. Richardson B. and Writer in [10] argued that the credibility of workers who work from home improves due to the development of modern information technology. This technology has improved the performance of employees and organizations by establishing real-time connections between digital and physical systems, increasing flexibility, speed, and quality so that it can affect performance [11].

The impact of WFH on workers' performance is still inconclusive. Krasulja et al. [4] argued that WFH allows workers to express their creativity because the environment and office working schemes stress them out and affect their produc-tivity. WFH also creates a balance between work and personal life that affects a worker's daily activities [12]. Revenio C. Jalagat and Jalagat [13] stated that the performance of workers who work from home improved significantly because they feel free from office rules and save time for coffee breaks. Peeters [14] surveyed 500 workers who did not work from offices (including WFH) in the United States and found that these workers are more satisfied with their work, feel more valued because they are trusted even though they are not physically observed at work. Richardson B. and Writer in [10] argued that as modern information technolo-gy improves, the credibility of workers who work from home also continues to improve.

The ability to use technology affects the adjustment capability of workers to change working arrangements from their offices to their homes [15]. According to Hill et al. [16], technology allows workers to have flexibility in working time and location. The use of in-formational and communication technology (ICT) and advanced technology gen-erate performance by cumulative learning and repetitive opportunities in using ICT [17],[18],[19],[20],[21],[22]. The use of tech-nology relies on working facilities where unhealthy and unsupported working facilities affect the quality of workers' performance through worker's satisfaction [23].

To improve workers' performance during WFH due to the Covid-19 pandemic, technology use should be in line with Industry 4.0 characteristics as it addresses information, communication, and production issues. For example, cloud computing fulfills the need to share, model, and optimize output based on large datasets [2]. Industry 4.0 is also used in the firm's decision-making process as the technology of Industry 4.0 supports managers in predicting and making probabilistic inferences [2]. Kurt [24] mentioned that industry 4.0 focuses on end-to-end digitalization of all physical assets and integration of digital ecosystem value chains through ICT.

Technology related to working from home is the technological supporting work that can be done remotely, especially digital technology in information and communication. Javaid et al. [25] mentioned that during the Covid-19 pandemic, people need cloud computing to provide faster innovation and flexible re-sources through digital activities. Industry 4.0 related technology delivers real-time-capable horizontal and vertical internet-based connectedness of people, machines, and objects, as well as information and communication technologies for the dynamic management of complex business processes [26],[27].

The workers' performance is influenced by a worker's motivation and commitment. Motivation is defined as the entire needs and processes that positively affect the goal's attainment [28]. Olomolaiye [29] showed that bricklayers' motivations significantly affect the working time used productively. Awan and Tahir [30] found that support from the supervisor is the biggest factor affecting a worker's performance. Maslow [31] introduced the pyramid structure of human basic needs in which from the bottom to the top are physiological, safety needs, belongingness and love needs, esteem needs (prestige and feeling of accomplishment), and self-actualization. Such basic needs affect a worker's motivation in achieving a company and a worker's goals. Commitment is another factor that determines a worker's performance. Nink [32] argued that the engagement of workers which relies on a manager – workers' relationship is used to predict a firm's productivity. Kimball and Nink [32] added that workers who had a strong commitment tend to perform better and can take a risk for a company's goal. To sustain the engagement feeling of workers, the managers and workers need to have a strong relationship and effective communication [30].

Workers' performance is also determined by educational attainment. Human capital is one of a worker's productivity determinant factors as human capital is measured by the average years of schooling of a worker [33],[34]. The higher educational level of a worker creates a higher human capital level. Human capital is associated with the ability of workers to absorb and apply technology. The effectiveness of knowledge and technology transfer depends on the absorptive capacity of workers [35],[36],[37],[38],[39],[40].

Other individual characteristics that affect workers' performance are gender and age. Ali [41] showed that gender-focused policies positively determine the performance of an organization's member. Abraham et al. [42] uncovered that different gender does not affect behavioral performance, even though the brain activities between male and female show differences. Ali et al. [43] showed that the impact of gender diversity on an organization's performance in Australia depends on the context of the industry. Regarding the impact of worker's age on worker's performance, Ng and Feldman [44] showed that worker's age does not have any relationship with core task performance, but worker's age has a relationship with general counter-productive work behavior. Therefore, the general impact of workers' age on workers' performance is still inconclusive.

The characteristics of the location where a company is established, and the characteristics of jobs also affect a worker's performance. Le and Pomfret [45] argued that a company gains the benefit from good infrastructure developed in a certain province where a company is located.

Access to knowledge and technology is also determined by the location of a company [46],[47]. In the other words, locations that have good infrastructure and have large knowledge accumulation, such as having many human capitals, universities, and public research institutes, benefit companies by increasing access to knowledge and technology resources, thus affecting workers' productivity.

This study examines the main factors that affect workers' performance during the implementation of WFH policy during the Covid-19 pandemic. According to literature review above such factors consist of technology use, motivation, commitment, stress, education, age, gender, public officer, public officer, professional jobs, and Java Island. Table 1 shows the hypothesis that examines the relationship between each of these factors on workers' performance.

III. DATA SOURCE

The data is sourced from an independent online survey initiated by the research team of science, technology, and innovation human resource development from the Research Center for policy and Management of Science Technology and In-novation, Indonesian Institute of Sciences. The targeted respondents are those who must change their working environment from working from the office to working from home across the Indonesian provinces. The total respondents are 966 people. Table 2 shows the data description of this study.

IV. THEORETICAL FRAMEWORK

Workers' performance is determined by the technology that creates a new supporting environment that enables firms to increase the output [23],[17],[18],[19],[20],[21],[22]. Such an environment should be supported by self-internal factors such as motivation, commitment, and stress that increase or decrease workers performance [30],[32],[9],[31],[29],[48]. The workers' performance is also determined by a worker's educational background that determines the human capital of the companies [33],[34]. Other factors that affect a worker's productivity are the worker's age and gender [42],[41],[49],[44]. This study also controls time invariant-unobserved heterogeneity due to different professions and locations by including dummy variables of professional jobs, public officers, and the workers who live on Java Island [45],[50].

Table 1. The Hypotheses (H1)

Factors	Expected Relationship with Productivity (H1)
Technology Use	+
Motivation	+
Commitment	+
Stress	-
Education	+
Age	+/-
Gender	+/-
Public officer	+/-
Professional Jobs	+
Java Island	+

Table 2. The Data Description

Variable	Obs	Mean	Std. Dev.	Min	Max
Productivity**	966	1.242	4.325	0.024	63
Technology Use*	966	4.483	1.782	2	10
Motivation*	966	11.675	1.694	6	15
commitment*	966	11.494	1.649	3	15
Stress*	966	10.881	2.004	4	15
Education**	966	3.362	0.791	1	5
Age**	966	4.918	1.861	1	8
Professional***	966	0.544	0.498	0	1
Gender***	966	0.494	0.500	0	1
ASN***	966	0.287	0.452	0	1
Java***	966	0.857	0.350	0	1

Notes: *) The values are the total summation of ordinal data of each variable. **) The values are the calculation result based on productivity measurement (productivity) in this study or based on ranking classification (education and age). ***) The values are binary data (0 and 1). For a Gender variable, 1 is male and 0 is female. For a professional variable, 1 is professional workers and 0 is non-professional workers. For Public Officer, 1 is public officer except for lecturer and teacher and 0 is the non-public officer. For Java Island, 1 is for workers living in Java Island and 0 is for workers living outside Java Island.

The relationship between worker's performance (WP) and its determinant factors can be written as the following function.

$$WP = f\{\text{technology use, motivation, commitment, Stress, Education, Age, gender, professional jobs, public officers, Java Island}\}$$

WP is constructed by the following formula:

$$WP_i = \frac{hours\ for\ WFH\ a\ day}{hours\ for\ WFO^1\ a\ day} \cdot \frac{days\ for\ WFH\ per\ week}{days\ for\ WFO\ per\ week} \quad (1)$$

This study assumes that the more time spent on working, the higher performance it is. Bloom, Liang, Roberts, and Ying [3] showed that working from home increases performance by 13% of which is 9% due to the longer time used for working.

$$\begin{aligned} WP_i = {} & \alpha + \beta_1 Ind_i + \beta_2 Motiv_i + \beta_3\, Commit_i + \beta_4 Stress_i \\ & + \beta_5 Edu_i + \beta_6\, Age + \beta_7 Male_i \\ & + \beta_8\, Prof_i + \beta_9 PO_i \\ & + +\beta_{10} Java_i + u_i \end{aligned} \quad (2)$$

Where WP_i is worker's performance of worker i. Ind_i is a technology used by worker i. $Motiv_i$ is the level of motivation of worker i. $Commit_i$ is the level of worker i. $Stress_i$ is the level of stress of worker i. Edu_i is the level of education of worker i. Age_i is the age of worker i. $Prof_i$ is a dummy variable for a worker who has a professional job. PO_i is a dummy variable for a worker who works as a public officer. $Male_i$ is a dummy variable for a male. $Java_i$ is a dummy variable for a worker who lives on Java Island. u_i is the error term.

V. Empirical Findings

Table 3 shows the empirical findings of this study. The result shows that technology use is one of the determinant factors of workers' performance during WFH. All models show that technology positively contributes to workers' performance with a significant level, mostly at 1%. This result indicates that the technology is necessary to increase workers' performance during WFH due to Covid-19. This result aligns with the argument that technology can generate worker's productivity [17],[18],[20],[21],[22].

The result of Model 2 in Table 3 shows the impact of additional factors which are self-generating factors represented by motivation, commitment, and stress on worker's productivity. The result shows that technology still contributes to workers' performance. Motivation is a leveraging resource factor to increase workers' performance which can be seen from an additional increase of R2 from 0.0195 to 0.0368 with a significant level of difference at a 1% level. Adjusted R2 also increases significantly from 0.0185 to 0.0328 showing the significant impact of self-generating factors especially motivation in increasing worker's performance. This result aligns with [30] which shows that motivation increases time used productively.

Model 3 adds an educational background of a worker into the model and shows a slight difference from the result of Model 2. The R2 difference of Model 3 is only 0.003 and its difference is not statistically significant, even though the adjusted R2 slightly increases from 0.0328 to 0.0343. The result of Model 3 in Table 3 shows that technology and motivation still contribute positively and statistically significant at a 1% significant level on worker's performance. The result also shows that educational background has a positive impact on workers' performance, but its impact is statistically insignificant.

Model 6 adds a geographical factor as one of the workers' performance determinant factors. The result in Table 3 shows that the geographical factor significantly determines a worker's performance. On average, workers who live on Java Island have higher performance than those who live outside Java Island with a significant level of 5%. Adding geographical factors makes a statistically significant difference from Model 5 with a significant level at 5%. This result is in line with the expected result as infrastructure and human capital in Java Island are better than those outside Java Island. This result aligns with the argument that a geographical factor determines a worker's performance [45]. Models, 7 – 10 in Table 3 include joint variables to investigate whether Industry 4.0 is affected by gender, age, and job characteristics. The result shows that the impact of Industry 4.0 on workers' performance does not rely on different gender, ages, and job characteristics. The R2 difference for models 7 – 10 is 0.00 and the difference of each model from Model 6 is not statistically significant. This result indicates that Technology plays a vital role in increasing workers' performance without differentiating gender, age, and job characteristics.

Table 4 shows the determinant factors of a worker's performance based on job characteristics. Models 11 and 12 in Table 4 focus on public officers and non-public officers, respectively. Meanwhile, Models 13 and 14 focus on professional jobs and non-professional jobs, respectively. The result shows that the performance of public officers is determined by technology, motivation, and the company's location, while the performance of non-public officers is determined by technology, motivation, education, and the company's location. The performance of workers who have professional jobs is determined by technology, motivation, and the status as a public officer or not, while the performance of workers who do not have professional jobs is influenced by technology, motivation, the status (as a public officer or not) and whether the workers living in Java Island or not.

The other control variables do not show a significant contribution to the worker's performance, but the sign of each coefficient aligns with the expected results. Stress negatively affects a worker's performance and a worker's commitment positively affects a worker's performance. However, those relationships are not statistically significant which indicates that the workers' performance during WFH due to Covid-19 is not significantly determined by the worker's commitment and worker's stress level.

VI. DISCUSSIONS

This study shows that technology use has a positive impact on workers' performance during WFH due to the Covid-19 pandemic. During WFH, the use of technology certainly increases since workers need technology to support their work at home. The technology used during WFH is mostly related to wireless technology and internet-based technology in which some of them align with Industry 4.0 characteristics which are autonomous actions independent from location, wide-spread integration, and various automated services [51]. Supporting infrastructure for communication in this condition is very necessary to avoid misunderstandings of the working process that lead to lowering workers' performance [49].

Providing technology infrastructure should be supported by the skills to operate the relevant technology during WFH. The empirical finding shows that educational background positively influences workers' performance even though such influence is statistically significant at 10%. The educational background, which can be measured by the average years of schooling, is associated with skills and the absorptive capacity [33],[34]. The result aligns with [36],[38],[37] which showed that human capital affects workers' productivity.

Regarding self-general characteristics represented by workers' age and gender, the result shows that those factors affect workers' performance insignificantly. The result suggests that the performance during WFH does not rely on how old or what gender a worker is. This result aligns with [42] which showed that different genders do not influence behavioral performance. This study also aligns with [43] which mentioned that workers' performance does not depend on gender.

Other factors that affect workers' performance come from self-generating factors represented by motivation, commitment, and stress level. The result shows that motivation is the most consistent factor that positively significantly affects a worker's performance. However, commitment and stress level does not affect workers' performance significantly.

Table 3. The Empirical Findings

Dependent Variable = Worker's performance	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Technology Use (β_1)	0.152*** 0.0346	0.137*** 0.0346	0.131*** 0.0348	0.133*** 0.0351	0.131*** 0.0351	0.120*** 0.0352	0.082* 0.0483	0.0840 0.0933	0.110*** 0.0396	0.129*** 0.0487
Motivation (β_2)		0.361*** 0.0944	0.359*** 0.0943	0.358*** 0.0945	0.359*** 0.0942	0.350*** 0.0941	0.348*** 0.0941	0.347*** 0.0943	0.350*** 0.0941	0.349*** 0.0941
Commitment (β_3)		0.0349 0.0937	0.0300 0.0937	0.0219 0.0951	0.0275 0.0950	0.0517 0.0954	0.0530 0.0954	0.0541 0.0956	0.0521 0.0954	0.0527 0.0955
Stress (β_4)		-0.0226 0.0685	-0.0234 0.0683	-0.0207 0.0686	-0.0315 0.0685	-0.0265 0.0684	-0.0238 0.0684	-0.0266 0.0684	-0.0256 0.0684	-0.0261 0.0684
Education (β_5)			0.0755 0.0471	0.0714 0.0478	0.0820 0.0498	0.087* 0.0497	0.090* 0.0498	0.087* 0.0497	0.087* 0.0497	0.087* 0.0498
Male (β_6)				-0.0016 0.0269	-0.0026 0.0268	0.0048 0.0270	-0.1102 0.1016	0.0052 0.0270	0.0048 0.0270	0.0048 0.0270
Age (β_7)				0.0040 0.0074	0.0059 0.0074	0.0037 0.0075	0.0039 0.0075	-0.0071 0.0265	0.0037 0.0075	0.0035 0.0075
Public Officer (β_8)					-0.08*** 0.0304	-0.09*** 0.0303	-0.09*** 0.0303	-0.09*** 0.0304	-0.1578 0.1219	-0.09*** 0.0304
Professional Job (β_9)					0.0108 0.0286	0.0106 0.0286	0.0101 0.0286	0.0112 0.0286	0.0104 0.0286	0.0355 0.1021
Java Island (β_{10})						0.092** 0.0391	0.090** 0.0391	0.093** 0.0393	0.092** 0.0391	0.092** 0.0391
Technology Use*Male (β_{11})							0.0805 0.0686			
Technology Use*Age (β_{12})								0.0155 0.0363		
Technology Use*Public Officer (β_{13})									0.0463 0.0833	
Technology Use*Professional (β_{14})										-0.0175 0.0689
Constant (α)	0.384** 0.0511	-0.509* 0.2957	-0.57* 0.2980	-0.574* 0.2985	-0.56* 0.2981	-0.67** 0.3011	-0.62** 0.3038	-0.62* 0.3254	-0.66** 0.3017	-0.69** 0.0689
Number of Observation	966	966	966	966	966	966	966	966	966	966
R2 Diff.		0.017	0.003	0.000	0.009	0.005	0.001	0.000	0.000	0.000
Prob > F (Difference)		0.001	0.110	0.864	0.013	0.019	0.241	0.669	0.579	0.800
R2	0.0195	0.0368	0.0393	0.396	0.0537	0.0537	0.0551	0.0539	0.0540	0.0538
Adjusted R2	0.0185	0.0328	0.0343	0.0326	0.0438	0.0438	0.0442	0.0430	0.0431	0.0429

Notes: Model 1 uses technology uses and working facilities as regressors. Model 2 adds workers' motivation and commitments as regressors. Model 3 adds stress and distraction as regressors. Model 4 adds a worker's age and gender as regressors. Model 5 adds joint variables, technology and gender, infrastructure and gender, motivation and gender, gender, gender, commitment and gender, gender, stress and gender, and distraction and gender. ***) Significant level at 1%; **) Significant level at 5%; *) Significant level at 10%

This result suggests that workers' performance during WFH due to the Covid-19 pandemic relies mostly on individual motivation. Even though workers can use Industry 4.0 related technology, their performance cannot be optimum. In terms of the working environment, the motivation can come from supervisor or manager support [30],[32] and workers' relationship [32].

This study divides respondents into two groups based on their location, respondents who stay on Java Island and those who stay outside Java Island, to control the impact of a different location on performance. As the expected result, the result shows that workers who stay in Java Island have greater performance during WFH than those who stay outside Java Island. The annual average number of the labor force with minimum senior or vocational high school attainment in Java Island reached more than 9 million or more than 60% of the total labor force. Those proportions can explain why the workers' performance in Java Island is higher than those outside Java Island.

VII. CONCLUSION

The empirical findings show that technology use significantly affects the worker's performance during WFH in Indonesia. Based on the results, workers' motivation is the highest leverage resource in increasing workers' performance. The performance of workers is also determined by a worker's educational background where the geographical differences are controlled in the model.

Table 4. Public Officer and Professional Jobs

Dependent Variable = worker's performance	Model 11	Model 12	Model 13	Model 14
Technology Use β_1	0.160*** 0.0461	0.108** 0.0448	0.112** 0.0453	0.123** 0.0551
Motivation β_2	0.335*** 0.1069	0.353*** 0.1256	0.351*** 0.1193	0.352** 0.1501
Commitment β_3	0.1356 0.1219	0.0228 0.1230	0.0554 0.1245	0.0588 0.1483
Stress β_4	0.0519 0.0824	-0.0437 0.0896	0.1173 0.0870	-0.1553 0.1079
Education β_5	-0.0056 0.0549	0.131* 0.0677	0.0797 0.0678	0.0794 0.0745
Age β_6	0.0003 0.0094	0.0035 0.0097	0.0057 0.0090	-0.0013 0.0128
Professional β_7	0.0307 0.0361	0.0061 0.0368	-	-
Public Officer β_8	-	-	-0.08** 0.0341	-0.09* 0.0574
Male β_9	-0.0195 0.0314	0.0148 0.0359	-0.0227 0.0325	0.0367 0.0450
Java Island β_{10}	0.093* 0.0481	0.089* 0.0509	0.0335 0.0471	0.161** 0.0657
Constant α	-1.046 0.3693	-0.603 0.3932	-0.94** 0.3733	-0.436 0.4930
Number of Observation	278	688	526	440
R2	0.1278	0.0402	0.0616	0.0602
Adjusted R2	0.0985	0.0275	0.0453	0.0405
Prob > F	0.0000	0.0010	0.0001	0.0015

Notes: ***) Significant level at 1%; **) Significant level at 5%; *) Significant level at 10%

The other factors, which are commitment, stress, age, and gender, do not significantly impact a worker's performance. However, the direction of the coefficient shows the same result as the expected results. A worker's commitment positively contributes to a worker's performance. Stress negatively affects a worker's performance. Age and gender show a positive and negative contribution to workers' performance depending on the selected models.

Even though technology used in this study refers to basic technologies, the result shows that these technologies improve workers' performance during WFH. Workers need to be familiar with new ways of working such as remote working in a virtual office, where this method of work aims to improve the performance of the workers themselves and the industry.

This study has practical implications by which the government and company managers know the determinant factors of workers' performance during WFH in the period of the Covid-19 pandemic and the role of technology such as cloud computing and project management tools on that performance. Thus, necessary actions and relevant policies can be done to sustain workers' performance during WFH, such as providing training and consultations for workers to develop their technology-related skills and to adjust the working environment in this pandemic. The implementation of working from home supported by Industry 4.0 related technology such as cloud computing and project management tools has been proven to support the performance of individuals and organizations.

VIII. RESEARCH LIMITATIONS

This study uses convenience sampling which is a part of non-probability sampling. This sampling technique cannot cover all population members, and each member has a different chance to be selected.

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