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COVID-19 Remote Work: Body Stress, Self-Efficacy, Teamwork, and Perceived Productivity of Knowledge Workers

Mikko Virtaneva

University of Jyväskylä, mikko.l.j.virtaneva@student.jyu.fi

Polina Feshchenko

University of Jyväskylä

Abrar Hossain

University of Jyväskylä

Antti Kariluoto

University of Jyväskylä

Joonas Himmanen

University of Jyväskylä

See next page for additional authors

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Authors

Mikko Virtaneva, Polina Feshchenko, Abrar Hossain, Antti Kariluoto, Joonas Himmanen, Pasi Kaitila, Joni Kultanen, Kai-Kristian Kemell, and Pekka Abrahamsson

COVID-19 REMOTE WORK: BODY STRESS, SELF-EFFICACY, TEAMWORK, AND PERCEIVED PRODUCTIVITY OF KNOWLEDGE WORKERS

Research paper

Virtaneva, Mikko, University of Jyväskylä, Jyväskylä, Finland, mikko.l.j.virtaneva@student.jyu.fi

Feshchenko, Polina, University of Jyväskylä, Jyväskylä, Finland, polina.p.feshchenko@jyu.fi

Hossain, Abrar, University of Jyväskylä, Jyväskylä, Finland, abrar.sk.hossain@jyu.fi

Kariluoto, Antti, University of Jyväskylä, Jyväskylä, Finland, antti.j.e.kariluoto@jyu.fi

Himmanen, Joonas, University of Jyväskylä, Jyväskylä, Finland, joonas.e.himmanen@jyu.fi

Kaitila, Pasi, Workspace Oy, Helsinki, Finland, pasi.kaitila@workspace.fi

Kultanen, Joni, University of Jyväskylä, Jyväskylä, Finland, joni.m.kultanen@jyu.fi

Kemell, Kai-Kristian University of Jyväskylä, Jyväskylä, Finland, kai-kristian.o.kemell@jyu.fi

Abrahamsson, Pekka, University of Jyväskylä, Jyväskylä, Finland, pekka.abrahamsson@jyu.fi

Abstract

Due to COVID-19, companies were forced to adopt new work processes, and reduce modern work environments such as collaboration spaces. Professionals from many fields were forced to work remotely, almost overnight. Little is known about the impact of such non-volunteer remote work on productivity, stress, and other key aspects of work performance. To further our understanding of the impacts of this situation and remote work in general, we conducted an exploratory study by studying 28 knowledge work professionals (researchers, software developers, interior designers, service designers, and development consultants) from the viewpoint of perceived productivity and aspects affecting it in this unusual setting. Early results showed the positive influence of self-efficacy and teamwork on productivity during remote work, while no moderating effect of measured physical stress on productivity either through the intrinsic or social factor was present.

Keywords: Perceived Productivity, Knowledge Workers, Remote Work, COVID-19.

1 Introduction

As a result of the COVID-19 pandemic that began in late 2019, remote work has become increasingly common in various areas. Some organizations were more prepared while some were caught off guard by the sudden need for remote working possibilities. All in all, companies had to adapt to better support remote work. From the companies' point of view, one major factor in remote work is productivity. Will the productivity of employees, either decrease or increase? Productivity and factors related to it have been extensively studied in the past in various contexts, but scarcely, in comparison, in the context of remote work.

Bao et al. (2020) already found that working from home had both positive and negative effects on developers' productivity, although most developers' productivity remaining the same. However, noting that measurement metrics, in this case, development environment logs, can cause bias, the authors

themselves also recommend further research on the topic to ascertain how productivity is composed (Bao et al., 2020). Research suggests that prolonged stressful non-voluntary remote work created by pandemic reduces cognitive capabilities (Boals, Banks, 2020). Since measuring the perceived productivity in the work-from-home setting is still under study, this paper aims to further our understanding of the issue by studying the knowledge workers' productivity during the COVID-19 quarantine period.

The unusual circumstances brought on by the pandemic may have not only influenced how individuals perceive their jobs, colleagues, and working environment but also how they perceive themselves and their own capabilities. For example, self-efficacy – an evaluation of one's own ability to complete a task at hand – is a well-studied intrinsic attribute that positively correlates with productivity (Cherian, Jacob, 2013; Gist, Mitchell, 1992; Phillips, Russell, 1994). The widespread layoffs may have had a negative effect on the self-efficacy of various individuals living in the constant fear of unemployment. Similarly, work-related stress is known to reduce individual productivity (Choo, 1986; Luxmi, Yadav, 2011; Shahu, Gole, 2008), and potentially teamwork performance (Dietz et al., 2017).

This sudden need for remote working possibilities undermined various existing communication and collaboration processes in organizations. In organizations where remote work was possible, professionals were suddenly moved from physical collaboration spaces and ergonomic offices to their homes, where they might not have had a proper work office at all. The non-voluntary nature of much of the remote work has negative impacts on workers (Kaduk et al., 2019). The authors argue that when remote work is done involuntarily it is associated with greater work-to-family conflict, stress, burnout, turnover intentions, and lower job satisfaction. In contrast, when done voluntarily remote work is associated with lower stress and intentions to change job. Many existing studies have linked group interaction at work and teamwork on tasks with notable increases in individual performance (Gallie et al., 2009; Hanaysha, 2016; Musriha, 2013). However, few studies exist on lengthened online teamwork and its effects on interaction. In information studies, especially the local culture in the company has many effects on the performance and effectiveness of IS usage and adoption (Avison, Myers, 1995; Weber, Pliskin, 1996; Melville, Kraemer & Gurbaxani, 2004). One criticism for remote work is its alleged erosive effect on company culture but instead, it seems that existing strong corporate culture would instead improve different information system usage and adoption (Li et al., 2020).

In this paper, we study the effects of remote work on the productivity of knowledge workers (n=28) by means of an empirical study utilizing survey and interview data. In doing so, we provide a measurement model to help understand what individual and social components formulate the perceived productivity in this context. The rest of this paper is organized as follows. In the second section, we present the related work, e.g., knowledge work, work-related stress, teamwork, and self-efficacy. In section 3, we discuss the data collection, processing, and explain the data analysis. In section 4, we showcase the research model, the justifications, and the related hypothesis. In section 5, the empirical results are presented. Section 5.1 has the results of the hypothesis testing, while section 5.2 includes the interviews. In section 6, we discuss these results, and section 7 concludes the paper.

2 Background

Knowledge work is the practice of applying accumulated knowledge and information at tasks, which mainly are knowledge-intensive (Davis, 2002) and produce mostly intangible outcomes. Thus, knowledge workers are professionals whose job consists largely of tasks related to applying human cognitive functions to their work. Meyer and Hünefeld (2018) define cognitive demands as a process of confrontation with new tasks, unpredictable developments, and knowledge acquisition, as well as problem-solving. As knowledge-intensive work involves similar activities, such as analysis, application of professional judgment, and solving complex problems, we feel it would be natural to unite these terms into a superordinate one, namely, cognitively demanding work. Examples of related occupations are systems analysts, programmers, accountants, managers, analysts, and lawyers (Alvesson, 2004; Davis, 2002; Von Nordenflycht, 2010).

Many studies on the productivity of knowledge workers and factors that influence it have been conducted (Erne, 2011). Existing studies have argued that knowledge workers from different occupations have different perceptions of what productivity is in their work, and which factors affect it positively or negatively. According to Erne (2011), various factors contribute to work performance of experts, including, for example, quality of group interactions and skill development. Graziotin, Wang, and Abrahamsson (2015) found in their study that in software engineering emotions, moods, and feelings have a linkage to cognitive processing activities and the productivity of individuals. During the pandemic, an emerging number of studies have been released considering productivity and remote work. Neto et al. (2020), Suresh and Gopakumar (2021), and Russo et al. (2021a) argue that most of the effects on productivity in knowledge work is related to organization and individuals and how they can cope and adapt to the current situation.

Knowledge and performance do not improve linearly, nor are they as important in every job context (Kilpi, 2016). Knowledge and information-based work performance, in particular, cannot be increased by improving processes (Beardsley, Johnson & Manyika, 2006). It can be argued that value in a modern business environment is not in processes or production but instead in interaction between people and customers (Kilpi, 2016; Lusch, Vargo & O'Brien, 2007; Laing, 2014; Laing, 2013). Melville, Kraemer, and Gurbaxani (2004) argue that it is essential to understand organizational culture when developing performance through information systems and even more when trying to improve economic performance (Weber, Pliskin, 1996). In many organizations, culture is merely acknowledged but it is not defined or utilized in the development of information systems (Avison, Myers, 1995). This is often due to culture being excessively difficult to define or study (Schein, 1990). In this study, the interviews provide some contextual insight into the company culture of the studied organizations.

Productivity in the context of knowledge work is more difficult to measure than productivity in traditional, more physical labor (Ramírez, Nembhard, 2004). However, according to a study by Haapakangas et al., (2018), productivity itself is a ratio between input and output, resources, and the produced product/activity. This is an objective way of measuring productivity; however, it does not tell the whole truth, and so a subjective way of looking at productivity is needed, which can be done, for example, by observing or surveying the employees (Haapakangas et al., 2018).

2.1 Work-related Stress

Stress involves a state of emotional arousal, unpleasantness, and loss of control. Stress has been linked to an increased risk of cardiovascular disease and loss of work productivity. Work-related stress, in particular, is considered to reduce productivity (Choo, 1986; Luxmi, Yadav, 2011; Shahu, Gole, 2008). This type of stress is any characteristic of a work-related environment that presents a threat to an employee. E.g., work stress can be a result of one's skills, capabilities, resources, or expectations not matching the requirements of the current work (Qadoos et al., 2015). During pandemic high-stress levels can be caused by how different personalities cope with the quarantine and reduction of social relations (Russo et al., 2021a). Suresh and Gopakumar (2021) found that software professionals working from home during pandemic feel mostly effective and benefit from remote work but would improve their efficiency if given more tools to engage in stress-relieving activities.

Electro-dermal activity (EDA) is an accepted indicator of changes in the autonomic nervous system and can be used to measure physiological stress. I.e., stress can be measured through changes in skin conductivity resulting from, e.g., sweating (Pakarinen, Pietilä & Nieminen, 2019). In this study, we utilize the Moodmetric Smart Ring to measure stress, which has been previously tested by Pakarinen, Pietilä and Nieminen (2019) for measuring stress.

2.2 Teamwork

Teamwork is largely regarded as an important tool for increasing overall productivity within organizations (Hanaysha, 2016). It can increase an employee's individual productivity, which contributes to overall organizational commitment (Gallie et al., 2009). In a team, employees can share knowledge and learn from others, resulting in shared learning (Hanaysha, 2016). Teamwork has also been linked with increased job satisfaction and higher individual employee performance (Musriha, 2013). Moreover, teamwork can empower employees and make them more autonomous, which, again, can improve organizational commitment, as well as reduce stress (Ooko, 2013).

Iterative interaction is an essential part of successful teamwork and is critical for organizational learning which has effects on organizational performance (Visser, 2005). Learning and interaction are always contextual in organizations (Avison, Myers, 1995; Kilpi, 2016), and thus, understanding context and organization's goals is essential. Learning and performance increase when the organization's goals and culture are aligned (Pentland, 2012; Namada, 2018). Therefore, the best use and adoption of information systems supporting learning through understanding local culture provides a prolific work environment (Enrique et al., 2001; Weber, Pliskin, 1996; Kilpi, 2016).

2.3 Self-efficacy

Self-efficacy is the "belief in one's capabilities to mobilize the motivation, cognitive resources, and courses of action needed to meet given situational demands" (Wood, Bandura, 1989). I.e., one's belief in their own abilities to complete a task at hand. It has been widely studied in the context of business organizations (Bandura, 1997; Stajkovic, Luthans, 1998), as well as in various other research areas.

High self-efficacy has been regarded as a positive factor in work environments. It has been associated with job satisfaction, job and academic performance, and better physical and mental health (Cherian, Jacob, 2013). For example, Gist and Mitchell (1992) stated that individuals with a higher level of self-efficacy are capable of more effectively dealing with difficulties and persisting in the face of failure. From the point of view of this study, we are mostly interested in the link between self-efficacy and job performance, which various extant studies have suggested (Cherian, Jacob, 2013; Gelso et al., 1988; Phillips, Russell, 1994).

2.4 Working Environment and Remote Work

COVID-19 accelerated change in how information systems are viewed, adopted, used, and monitored (Pan, Zhang, 2020; Dwivedi et al., 2020). Grant, Wallace, and Spurgeon (2013) argue that organizations and people need to adapt and learn new information systems and tools during remote work which has effects on well-being, trust, and productivity. Furthermore, they argue that knowledge workers differ in terms of their access to technology, their ability to work flexibly, and their individual competencies. Even though knowledge workers can work remotely it does not reduce the need for interaction and a shared work environment, but instead emphasizes them and changes their meaning (Laing, 2013; Kilpi, 2016).

Remote work encompasses concepts of anytime and anywhere computing, distributed working, teleworking, new ways of working, digital workplaces, and working from home. Flexible times and working places, according to Nijp et al. (2016), result in increased reported working hours, although the workers retain their usual working patterns. According to many studies, remote work either has a minimal impact on productivity (Bloom, 2014; Russo et al., 2021b) or can even increase it compared to working at the physical office (Haynes, 2005; Haynes, 2007).

The effects of the working environment on various factors have been studied extensively. For example, in terms of the physical work environment, open-office plans have been linked with a higher amount of short sick leaves (Bodin Danielsson et al., 2014), and indoor air quality has been linked with productivity

(Wong, 2013). However, the socio-behavioral work environment has been considered notably more important than the physical work environment in terms of productivity (Dul, Ceylan & Jaspers, 2011; Haynes, 2007). COVID-19 has changed behavior related to adopting and using IS during extended periods of remote work (Pan, Zhang, 2020). People need to seek, evaluate and share information in new ways and routines which then has effects on the company culture. It is argued by Li et al. (2020) that companies with strong organizational cultures are more resilient and are able to change more easily and thus have a competitive advantage. Some studies have also looked into perceived and self-assessed productivity in this context. In a study by Baker, Avery, and Crawford (2007), participants of the remote work-study answered surveys about their productivity and satisfaction in different cases. According to the study, organization structure, work characteristics, and financial support correlate directly with productivity. For employee satisfaction, the correlations were organization structure, work characteristics, HR/Management, and tech support. What did not correlate with either one were training and household characteristics.

It could be argued that those working from home often do so willingly and may have better time management skills and other qualities suited for it, which makes them more inclined to prefer remote work (Haynes, 2005). However, Bloom et al. (2015) studied remote work by randomly assigning workers to work remotely and still found that remote work increased productivity, as well as job satisfaction. In fact, many of their participants continued to work remotely, having found the experience positive. It would appear that the finding of Bloom et al. (2015) correlate especially to repetitive work with good working conditions. The authors point out that while there can be household-related distractions while working from home, more respondents described the home as a quieter working environment in comparison to office, which could explain why household characteristics do not seem to correlate with productivity.

Some individuals may have found it stressful to combine personal life and work-life in a new way inside the physical space, with other family members present. This has been linked especially to those with caring responsibilities (Ajjan et al., 2020). Those with caring responsibilities (most often women) can find it even more challenging to balance work and life at home. Initial evidence has been found that the lockdown has amplified gender stereotypes around the household (Ajjan et al., 2020). Therefore, it is no surprise that in some cases home can become more of a place of tension, especially when work and personal life boundaries blur. However, there are studies that imply (Choroszewicz, Kay, 2020; Eerola, 2014, Nordic Council of Ministers, 2018; Sümer, 2014) that the equality legislation in the Nordic countries such as Finland has provided more balanced caring responsibilities than in other more masculine cultures (Hofstede, 2021), even though, most of the caring is still done by women. Russo et al. (2021b) found in their study that the number of people present at home (whether babies or adults) did not correlate with time spent in different work activities. There are some that may have considered remote work a positive change. Blomqvist et al. (2020) found that in Finland in 2020 75 % of Finnish people working from home were able to balance work and personal life and 86 % were satisfied with remote work. Similar findings were found from Sweden where 87 % of respondents mentioned that they can keep the same level of engagement as usual and 94 % reported that they were collaborating well or very well with their colleagues (Bolander, Sumelius & Were, 2021). A recent study on productivity during the COVID-19 pandemic found that the productivity remained the same with most developers studied (Bao et al., 2020), although the situation had both positive and negative effects on their productivity. Overall, however, remote work has not been extensively studied, even though it has become an increasingly important topic in the wake of the COVID-19 pandemic. In this socio-cultural context and previous research findings, caring responsibilities were not included in the design of this study, even though, the topic is important.

3 Methodology

We utilized a mixed-methods approach following the definition of Johnson, Onwuegbuzie and Turner (2007) for this study. Johnson, Onwuegbuzie and Turner (2007) define mixed methods research as an

intellectual and practical synthesis based on qualitative and quantitative research; it is the third methodological or research paradigm (along with qualitative and quantitative research). We collected survey data, biometric data from a hardware instrument (a ring), as well as interview data. In the first subsection, we discuss the data collection in detail. In the second subsection, we discuss our data analysis methodology.

3.1 Data Collection and Processing

In total, 28 knowledge workers from two Finnish organizations participated in the study. Among them were researchers, software developers, interior designers, service designers, and development consultants. The data were collected over the course of four workdays during a lockdown period in April 2020. Three types of data were collected: (1) survey data, (2) biometric data from a hardware instrument (ring), and (3) interview data.

The respondents filled a pre-work and after-work questionnaire every day during the data collection period. The survey items of the post questionnaire were based on ones typically used in existing studies e.g., productivity, job satisfaction, work amount, quality of group interaction, communication, fatigue (Barrios-Choplin, McCraty & Cryer, 1997; Olguín, Pentland, 2008; Van der Vegt, Gerben S, 2002). The pre-questionnaire focused on self-efficacy and utilized the general self-efficacy measurement scale developed by (Chen, Gully & Eden, 2001). Both the pre-work survey and after-work survey utilized a 7-point Likert scale

For the biometric data collection, we utilized the Moodmetric Smart Rings® (www.moodmetric.com), which measure the activation of the sympathetic nervous system (SNS) through electrodermal activity (EDA) of the skin and produce an estimation on the stress level of the user (Pakarinen, Pietilä & Nieminen, 2019). Heikkilä et al. (2018) argue that the rings are capable of measuring different emotional changes such as nervousness or alertness with reasonable accuracy.

Finally, semi-structured interviews were conducted with randomly selected participants. This was done to add supporting data to the data set. In the interviews, the participants were asked general questions related to perceived productivity in remote work and were encouraged to elaborate on their answers through further, context-specific questions. The interviews were conducted one-on-one via Microsoft Teams and Skype programs during the first two weeks of June 2020. The recordings were then transcribed by hand and analyzed with the focus on productivity and teamwork.

The data collection period was four full working days. Afterward, each type of data was combined under respondent IDs, sorted, and cleaned. After cleaning the data, a total of 44 data points had all the necessary values and, thus, were included in the final dataset.

3.2 Data Analysis

For the analysis of the questionnaires data, the structural equation modeling (SEM) approach followed by the PLS method (Acedo, Jones, 2007; Adeleke, Bahaudin & Kamaruddeen, 2015; Chin, Frye, 2003) was utilized, to determine underlying relationships between different constructs and the predictive power of the research model presented in the next section (Alam et al., 2021). The PLS technique was chosen as it is more applicable in situations when the theory is inadequately grounded, and the variables do not have rigorously confirmed measurement models or fit a given distribution (Fornell, Larcker, 1981). This study used PLS-SEM as the study is more about exploratory research than confirmatory research (Hair Jr et al., 2016).

The PLS model interpretation consists of two steps: one, the evaluation of reliability and validity of the measurement model, and two, the assessment of the structural model (Acedo, Jones, 2007; Alam et al., 2021). This two-step process is followed to make sure the reliability and validity in making conclusions about relationships among constructs (Barclay, Higgins & Thompson, 1995). Thus, the PLS model is assessed in terms of factor loadings, construct reliability, discriminant validity, and convergent validity

(Acedo, Jones, 2007). The structural model is then evaluated using the R-square and individual path coefficients. Rigdon (2012) states R-square as in-sample predictive power. According to (Hair et al., 2019), R-square is a measure holding the power of explaining the research model. The model's direct and moderating effects are assessed by bootstrapping with 1000 subsamples and running the PLS algorithm in SmartPLS 3.0 software (Ringle, Wende & Becker, 2014).

For the analysis of the Moodmetric Smart Rings' data, the data was pre-processed to contain only the data points of those individual subjects whose Moodmetric data had pre- and post-questionnaires' counterparts from the same measurement day. The Moodmetric data had a stress-level per minute for each individual, while possible values ranging from 1 to 100. The authors calculated the mean of the stress-level from the Moodmetric data for each measurement day and further transformed the mean values to an evenly spaced 7-Likert scale. Two of the lowest mean values were removed since the data points were deemed to be exceptions that, instead of indicating stress, indicated a possible depression. The 7-Likert scale was designed to have a value of 1 within the range of $[50 - d, 50 + d]$ expanding with the fixed d outwards from the center of the sequence reaching the value of 7 within the ranges of $[1, 1 + d]$ and $[100 - d, 100]$, where d is the constant distance ($d = 50/7$). The Likert scale value of 1 depicted the normal, non-stressed values, while the Likert scale value of 7 meant that the test subject was under a heavy burden that takes a long time to recover.

4 Measurement Model

A review of the literature in the field of perceived productivity and productivity in the remote work context has shown the lack of study regarding the exact factors that affect productivity while working from home. As it has been found that effective teamwork activity can lead to increased employee performance (Musriha, 2013), and self-efficacy positively correlates with individual productivity (Gelso et al., 1988; Phillips, Russell, 1994), these constructs were chosen as foci for this study. Since stress is a well-known factor that influences our individual responses on cognitive, social, and behavioural levels, the moderation effects of it on either one of the two relationships are explored (Colligan, Higgins, 2006).

Based on the relationships identified in academic literature between self-efficacy, perceived productivity, teamwork, and stress, the following hypotheses are outlined:

- *H1. There is a positive relationship between self-efficacy and perceived productivity.*
- *H2. There is a positive relationship between teamwork and perceived productivity.*
- *H3. Stress has a moderating effect on the relationship between self-efficacy and perceived productivity.*
- *H4. Stress has a moderating effect on the relationship between teamwork and perceived productivity.*



Figure 1. The measurement model of perceived productivity.

5 Empirical Results

In this chapter and its subchapters, we present the empirical results based on the data model and the interviews, respectively.

5.1 Hypothesis Testing

After running the PLS algorithm, items having factor loading of .40 or more were retained in the final model for construct reliability (Wong, 2013; Hulland, 1999). As all items for the constructs had factor loadings of at least .40, none of them were dropped. For this study, the reliability of the constructs was assessed through composite reliability (CR) (Werts, Linn & Jöreskog, 1974; Wong, 2016). In table 1, all the values of composite reliability are more than .70, which is the cutoff value, as indicated by Nunnally, Bernstein (1978). Thus, all the constructs in the model were found to be reliable. Then the convergent validity was tested through average variance extracted (AVE) measure (Fornell, Larcker, 1981). As per Fornell and Larcker (1981), AVE values of at least .50 or greater were employed to measure convergent validity. Table 1 shows all the constructs having an AVE value of greater than .50, and thus the convergent validity of the model was supported.

	<i>Discriminant Validity</i>				Composite Reliability	Cronbach's Alpha	AVE
	<i>PRO</i>	<i>EFF</i>	<i>MMS</i>	<i>TW</i>			
PRO	1.000				1.000	1.000	1.000
EFF	.576	.873			.962	.954	.761
MMS	.122	.140	0.000		0.000	0.000	0.000
TW	.710	.546	.088	.796	.873	.806	.634

Table 1. Reliability, convergent and discriminant Validity. Notes: EFF- Self-efficacy, TW- Teamwork, PRO- Productivity, MMS- Stress.

Table 1 shows the assessment of discriminant validity, which looks into the criteria that the constructs analyzed are different, which means AVE needs to be greater compared to the variance shared between the construct and the other constructs in the research model (Acedo, Jones, 2007). To achieve discriminant validity, according to Barclay, Higgins and Thompson (1995), the diagonal values need to be considerably greater than the off-diagonal values in the corresponding columns and rows. As can be observed from table 1, all constructs fulfill the criteria; thus, the discriminant validity for the research model has been achieved. As the construct of stress was utilized in the model testing just for exploring the presence of moderation and not for predicting the relationship of any dependent variable or being in relationship with any, the reliability tests are zero, indicating no correlation with other constructs (Bagozzi, Yi & Phillips, 1991).

The study results of the direct relationships are presented in Table 2. The R-square of .556 shows that 55.6% of the variation in the perceived productivity can be explained by the differences in the given independent variables- Self-efficacy, Teamwork, and Stress. It was found that self-efficacy has a positive relationship with perceived productivity (Beta= .264), and the relationship is significant, with

a T-value of 2.032 ($T > 1.96$). Thus, H1 is supported. Similarly, Teamwork was also found to have a positive relationship with perceived productivity ($Beta = .562$), and the relationship is significant, with a T-value of 3.823 ($T > 1.96$). Thus, H2 is also supported.

	<i>Path</i>	<i>R-Square</i>	<i>Beta</i>	<i>T-value</i>	<i>Sig. (p)</i>	<i>Decision</i>
H1	EFF→ PRO	.556	.264	2.032	0.042	Supported
H2	TW→ PRO		.562	3.823	0.000	Supported

Table 2. Results of hypotheses testing for productivity factors (direct relationships).

The study results of the moderating effects presented in table 3 show that the moderating effect of stress on the relationship between Self-efficacy and perceived productivity is not significant as the T-value is 1.152 ($T > 1.96$). Thus, H3 is not supported. Similarly, the moderating effect of stress on the relationship between Teamwork and perceived productivity is also not significant as the T-value is .685 ($T > 1.96$). Thus, H4 is also not supported.

	<i>Path</i>	<i>Beta</i>	<i>T-value</i>	<i>Sig. (p)</i>	<i>Decision</i>
H3	EFF*MMS→ PRO	-0.205	1.152	0.249	Not Supported
H4	TW*MMS→ PRO	0.108	0.685	0.493	Not Supported

Table 3. Results of hypotheses testing for moderation effects of stress on productivity.

5.2 Interviews

The respondents discussed various topics related to teamwork and productivity. In general, most thought that working together in some way has had a meaningful impact on each other's productivity, creativity, and indirectly to satisfaction. One respondent stated that they preferred working from home because of the freedom it brought in terms of choosing where and how to work. Some, on the other hand, found it more challenging to work remotely. This was e.g., due to the missing the social cues that are present in usual office work, or their tasks not being well-suited for working alone. The respondents generally considered teamwork essential for productivity.

The following list is comprised of some of the quotes from the one-on-one interviews.

"[...] Although I did not have any concern for COVID-19, I had a lot of concern about my salary, job security... I miss meeting people. [...]"

"[During remote work] we are working on the same document, everyone is collaborating, I think this is a great way to work. So far, what I have heard is that everybody is very happy except that we don't see each other. Well, I like working with people. We generate many ideas, then we grow through them."

"Usually in the office, we would go to a person and say let's go through this. Instead, now we have to arrange everything."

“But also, the good point was there – the mornings were so quiet and silent... So, there was no face-watching all of the time... that I have to be there at this time... Because I could start this at home. So that was good.”

When asked about the impact of the COVID-19 pandemic and the related remote working on a personal level, some respondents reported that they felt stress or anxiety. The reasons for the stress varied from the COVID-19 situation to personal issues. While some respondents felt lonely and missed social contact, the regular online meetings were considered to help in some cases. Yet, the respondents also discussed that it was far more formal to arrange meetings remotely, as opposed to simply walking over to someone’s office to talk about something.

Based on the interviews, opinions on remote work were divided. Some were well accustomed to remote work or grew accustomed to it, while others hoped to return to normal office work as soon as possible.

6 Discussion

This section provides a discussion of the empirical findings and implications derived from the study. The findings are also linked to the related works and previous research on the topic. The discussion is followed by the limitations that were present in the study.

6.1 Empirical Results and Implications

The topic of perceived productivity of knowledge workers is broad, as could be noted from the literature reviews in this paper. First, there are peculiarities in the routines of different types of knowledge workers, and in many studies, they have been rather separated by their occupation than united (Erne, 2011). This study, on the other hand, strived to unite several kinds of knowledge workers and did not distinguish between different types of knowledge work. The aim of this experiment was to explore what might explain the self-perceived productivity of knowledge workers in the context of remote work.

In this chapter, the results from the data analysis will be explained, and Primary Empirical Contributions (PECs) will be listed and discussed from the academic point of view, along with their potential managerial implications.

PEC 1: The personality attribute of an individual, such as the perception of one’s own capabilities to perform the task (self-efficacy), does explain the employee’s evaluation of their own productivity.

Self-efficacy as a personal characteristic of an individual has a positive impact on his or her productivity, meaning that those who have higher self-efficacy and are more confident in their own capabilities turn out to be more productive as well. In terms of managerial implications, this factor could be taken into account primarily when assigning tasks or hiring new employees, as those with higher self-efficacy might outperform those with lower ones on the same task or in new, unexpected circumstances. This empirical finding turned out to be consistent with the previous research on self-efficacy and productivity (Cherian, Jacob, 2013). In the interviews, the feeling of the self-perceived efficacy was mentioned when working with virtual collaboration tools:

“It feels it’s been more effective working on Teams than at the office. I feel we’ve been working more effectively in that way.”

Other recent studies of remote work and productivity have implied that the impact in productivity is not binary (Neto et al., 2020) and improving weaker attributes to improve efficiency and teamwork (Suresh, Gopakumar, 2021) providing a spectrum of possible variables explaining productivity in knowledge work. Studying perceived productivity in the context of the recent pandemic, unstable economic situation, and remote work have brought additional value in this research area, as it has shown that self-efficacy still correlates with perceived productivity of the knowledge workers and, thus, should be borne in mind if the productivity, for example, lowers, then it might turn out that the individual’s self-efficacy has decreased due to external circumstances.

This study also highlights the importance of considering and supporting individual readiness and attributes to work remotely and adopt new information systems, thus improving the organization's resilience to change and extremities such as COVID-19.

PEC 2: Quality of group interaction and level of achieved collaboration (i.e., teamwork) has a positive correlation with the perceived productivity of knowledge workers.

Teamwork is already known for being an important factor that contributes to the overall productivity of employees (Hanaysha, 2016, Musriha, 2013). However, as most of the studies were focusing on the traditional teamwork and interactions within the office, studying how people perceive and how it affects their productivity when it is online every day was an interesting angle to explore. It turned out that even during remote work quality of group interaction and the amount of teamwork have had a huge impact on the perceived productivity of knowledge workers.

The data obtained from open-ended interview questions regarding the overall impact of the pandemic on participants' work had revealed several points of interest that also supported this PEC:

"We have a lot of team meetings with colleagues over the internet. All those days go much better and go a lot quicker compared to the ones when I am alone just doing the work."

Two out of five interviewees, even though not asked directly, have noted that the collaboration and teamwork were helping them a lot and appreciated it quite a lot. Among the mentioned problems were lack of face-to-face contact and inability to see the body language of others. Nevertheless, the participants still reported the positive effect of teamwork on their productivity, which was also supported by the questionnaires' data and measurement model testing.

In terms of the implications, this finding indicates that having everyone working in the office might be unnecessary, as long as a sufficient amount of interaction and teamwork with colleagues is maintained. Basically, providing more freedom for the employees to choose whether to work from home or in the office should not hinder their productivity and commitment and, thus, should be considered by organizations.

PEC 3: *There is no moderation effect of biometrically measured stress on perceived productivity through either teamwork or self-efficacy.*

As the empirical results show, biometric stress does not moderate the relationships of factors that formulate the perceived productivity of knowledge workers. This result might happen mainly because some people might be stressed, no matter how productive they are. For example, some people can be very stressed when they are not productive, and at the same time, others who are very productive might be under pressure and also stressed or might be just aroused (Qadoos et al., 2015). This finding is supported also by Russo et al. (2021b) who found that while stress has an effect on well-being, well-being was unrelated to time spent in tasks. Overall, the finding from this study shows that no matter how the person is stressed, it does not moderate the effect of either teamwork or self-efficacy on the perceived productivity of an employee. Thus, these social and personal factors have such a strong relationship with productivity that it makes stress moderation of productivity weak, as the model testing results have also confirmed.

As some people also noted in the interviews, the presence of teamwork and interaction with colleagues have made them be more relaxed, which can also be a possible explanation of why stress has shown no influence on their performance.

PEC 4: *Remote work seems to have raised the threshold for initiating contact with the other party compared to office situations.*

It seems that remote working has raised the threshold for contacting other's colleagues compared to contacting the other party at the office. This seemed to hold true in cases where workers were looking to teamwork on topics, they needed help with or wanted to ideate. It is yet unclear what might be causing this threshold. (Chadburn, Smith & Milan, 2017) did initially notice resistance when knowledge workers

were instructed to move to open-plan offices from their private offices, and later these open-plan offices were accepted by the workers. Thus, it might be that the interviewees' current threshold is something related to the resistance to change that will go away; or maybe they simply do not want to bother the other party in fear of mixing work life and personal life (Davis, 2002), even though social contact itself was desired by all of the interviewees.

6.2 Limitations

The present paper represents the first stage of a longitudinal study and is less representative in terms of the findings. This also limits it in terms of generalization of the results and drawing conclusions on the focus area of the study. Besides, it is important to mention that it was a huge challenge to ensure that all the participants have been following all instructions, as the experiment was completely remote, and participants were not under any control. That resulted mainly in the severe reduction of data for the final dataset, as, for instance, some of the participants were not wearing the ring but still filling the questionnaires and, thus, were not included in the final analysis. Moreover, it could not be ensured that all the participants have done the calibration of their ring (should be worn for 12 hours since the start of the use), even though that should not impact the obtained results much, since almost half of the participants took part in the pre-pilot session. Thus, their rings were calibrated. The research was relatively short as well, so obtaining more biometric data in the longer-term research might provide different findings. Some of these are related to long-term effects of stress which were covered more in the background section but could not be studied extensively in this study. Among others, there are also construct validity threats that might come from the self-assessment of constructs (e.g., productivity) under study by the participants.

7 Conclusions

In this study, we investigated the impact of remote work on the productivity of knowledge workers during the COVID-19 pandemic. We focused on the constructs of self-efficacy, teamwork, and biometric stress, which we measured using mixed-methods research. In the later stages of this research, an additional construct might be created, potentially dealing more with working environment perceptions.

The findings in this study suggest that self-efficacy as a personal characteristic of an individual has a positive impact on his or her productivity, quality of group interaction and level of achieved collaboration (i.e., teamwork) has a positive correlation with the perceived productivity of knowledge workers, there is no moderation effect of biometrically measured stress on perceived productivity through either teamwork or self-efficacy, and remote work has raised the threshold for initiating contact with the other party compared to office situations.

We believe that this study will contribute to the formulation of a richer analytic framework for behavioral sciences, as it will help to understand how the performance of the knowledge workers can be improved and what can be possible factors affecting it. Besides, it is also well-known that in the later years, the practice of working remotely has become much more common, especially among knowledge workers who perform cognitive tasks (Baker, Avery & Crawford, 2007; Bloom et al., 2015). The findings from this study could be benefiting several research areas, such as organizational psychology or any other field that studies cognitive professionals, the nature of their work, and possible factors influencing it.

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